IMPLICATIONS OF SITE SPECIFIC RESPONSE ANALYSIS

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Site Specific Response Analysis

Local seismic hazard assessment

Fault type, fault distance, magnitude range, rock outcrop hazard spectra

Input Ground Motion

Hazard compatible real or simulated acceleration time histories

Site Characterization

Soil stratification, characteristics of soils based on borings, geophysical investigations, laboratory and in-situ tests

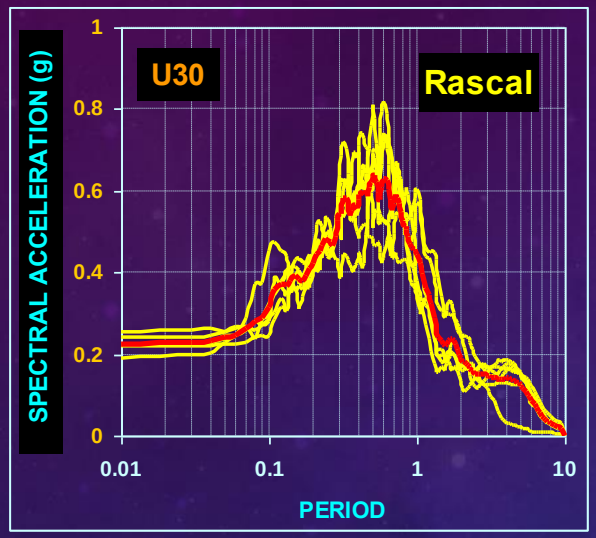
Soil Models

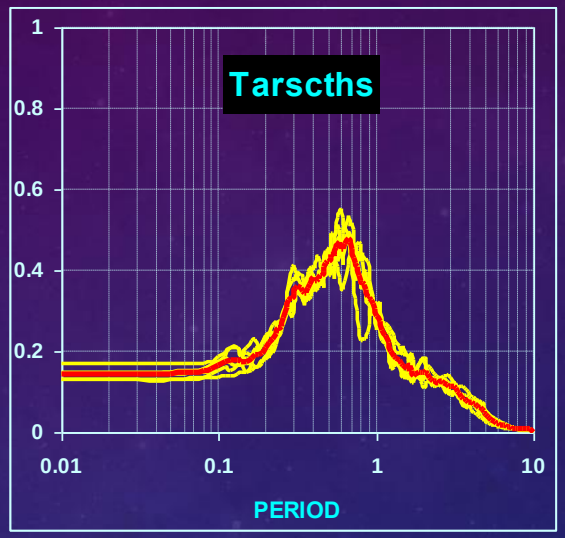
Equivalent linear or nonlinear inelastic cyclic behavior of soils in terms of total or effective stresses

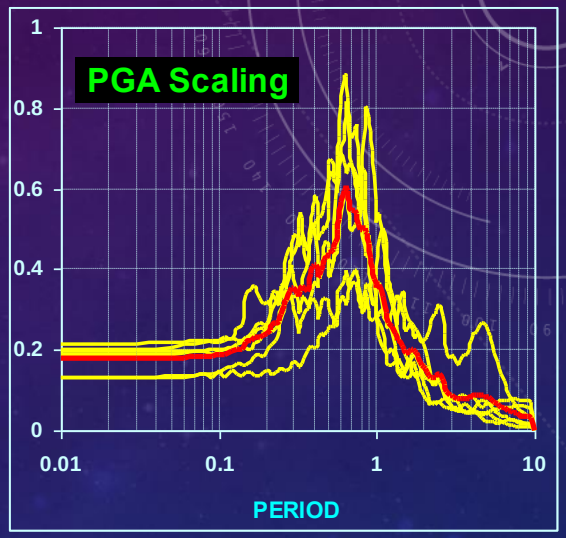
THE MAJOR UNCERTAINTIES

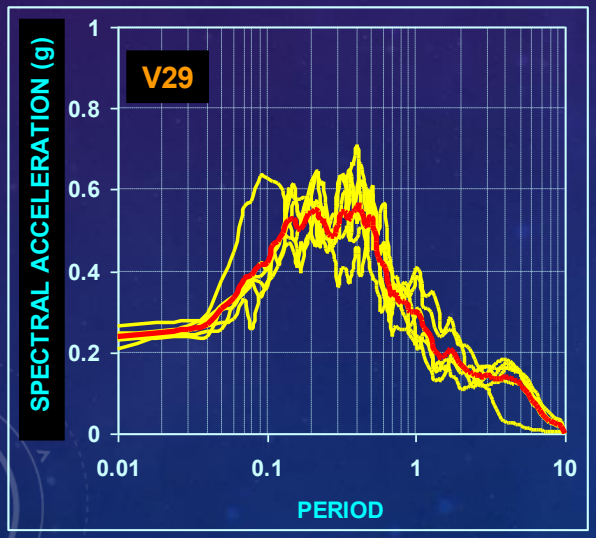
a. Local seismic hazard assessment,
b. Selection and scaling of the input earthquake time histories,
c. Soil stratification and engineering properties of soil layers,
d. Method of site response analysis.

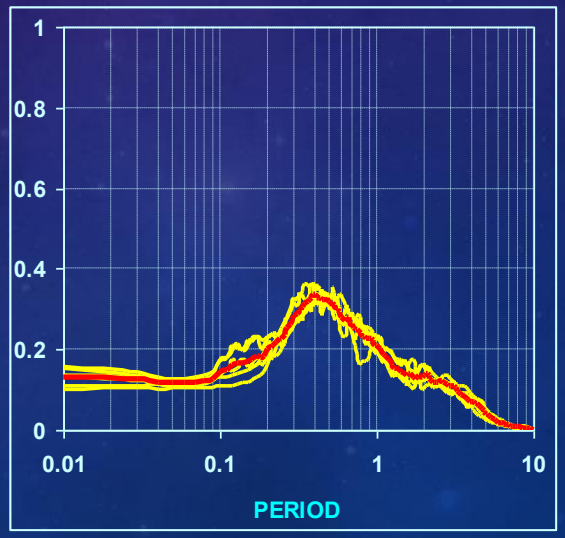
Effect of input motion selection on site response analyses for two soil profiles

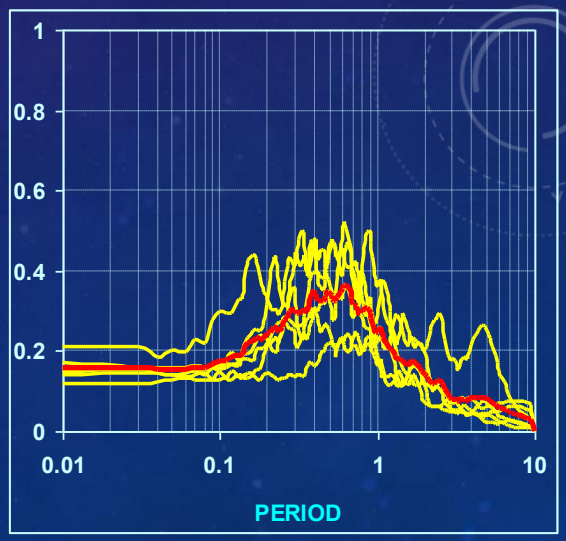




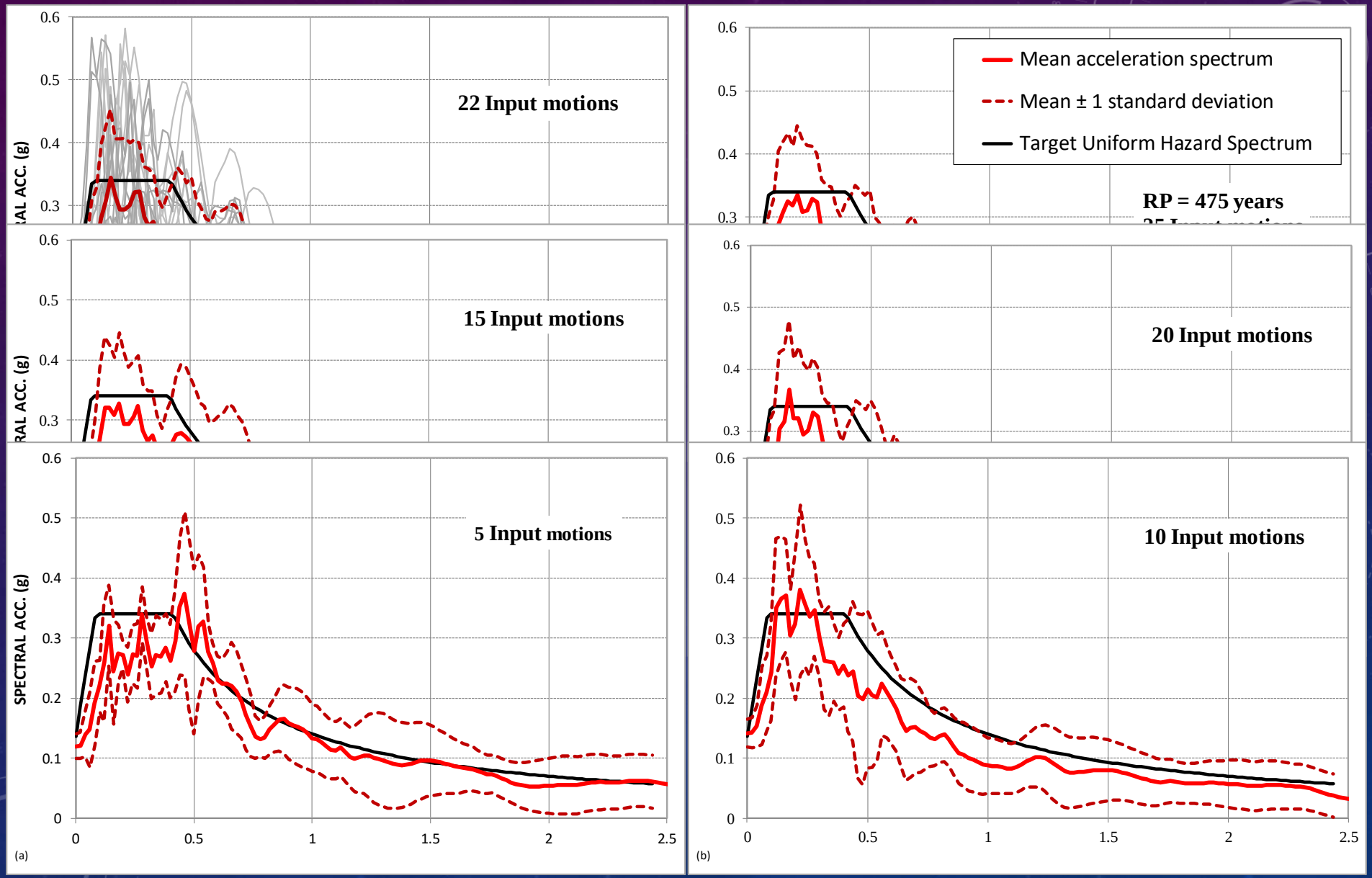




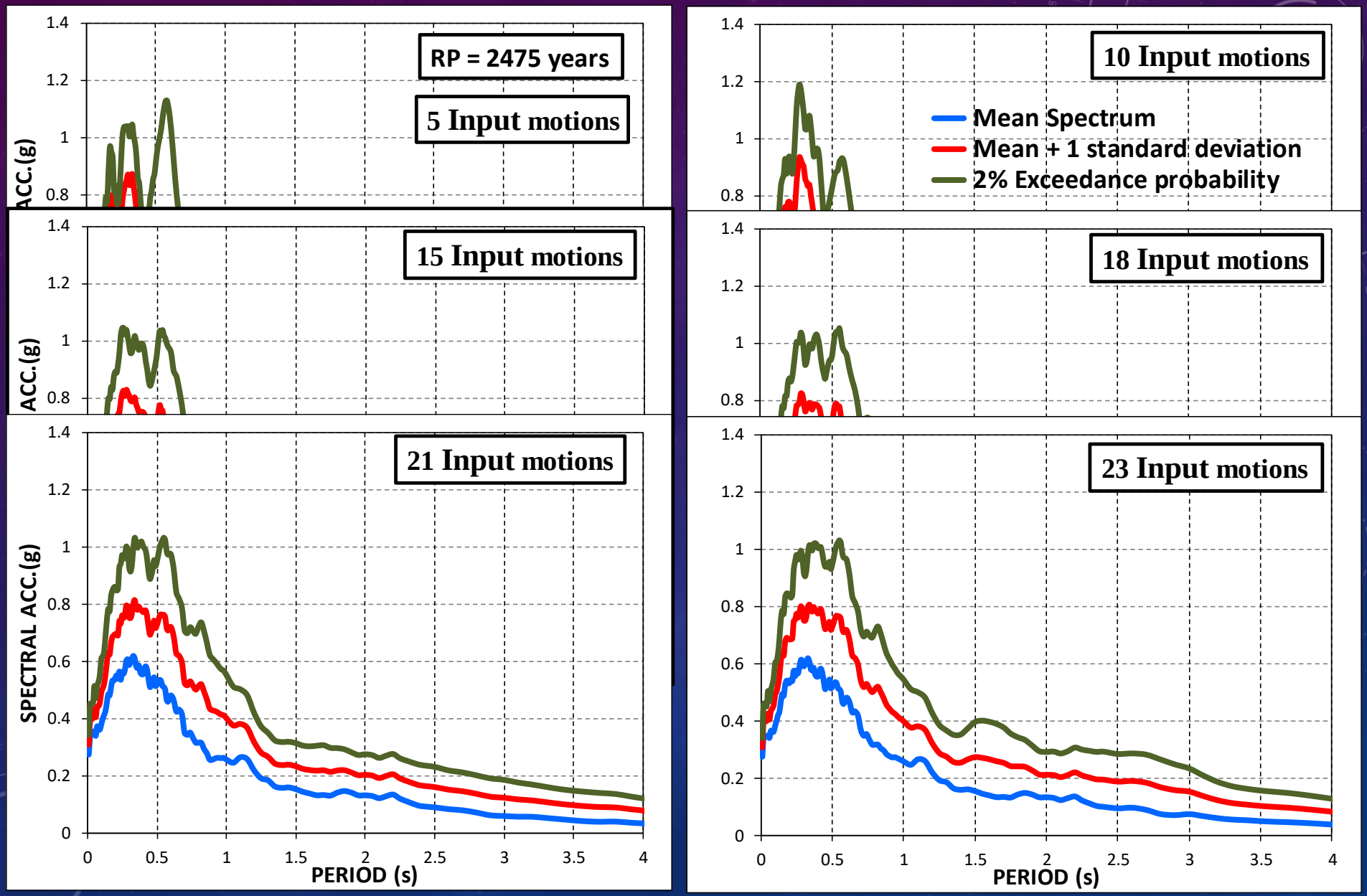




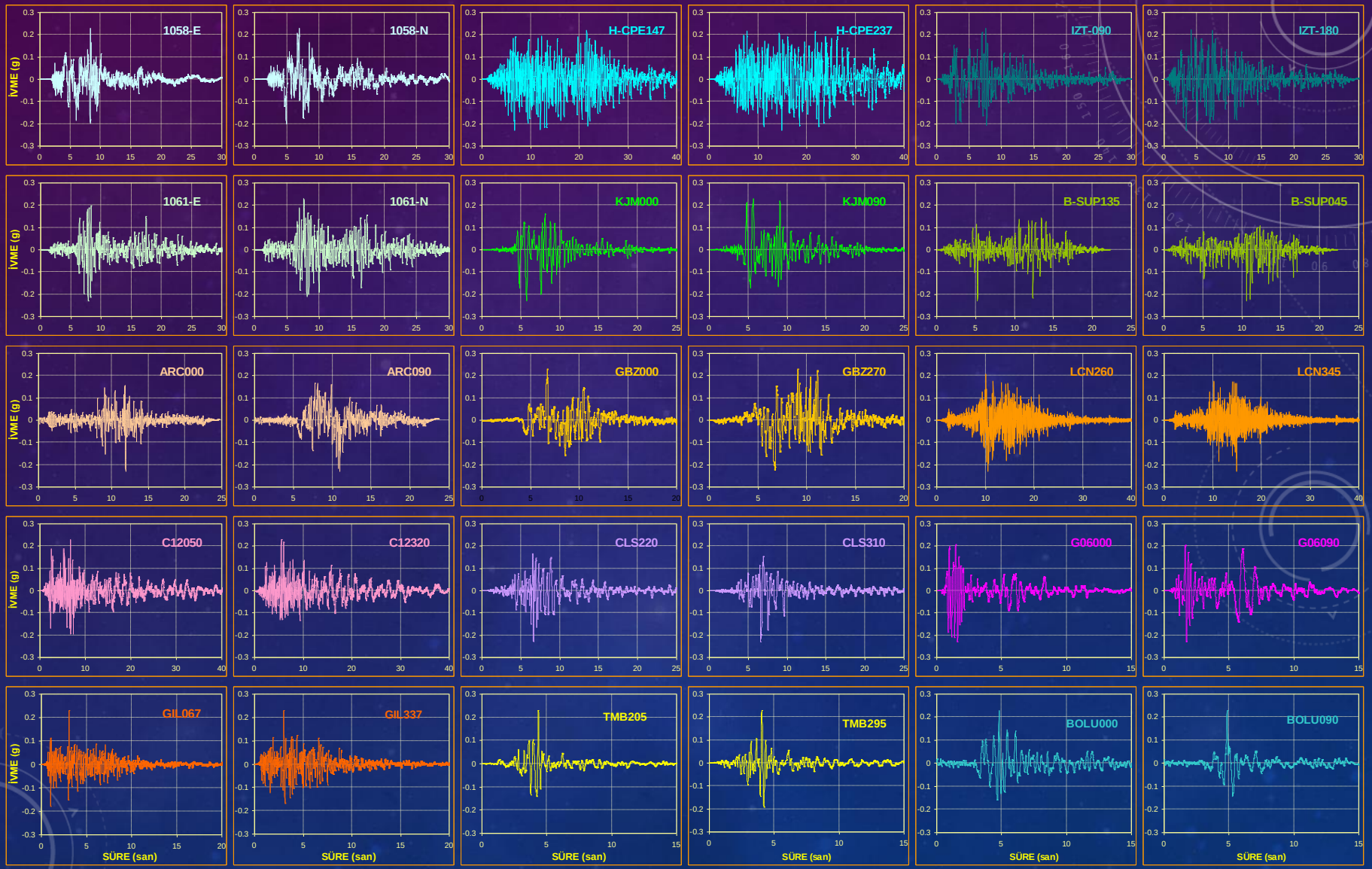
NUMBER OF SELECTED HAZARD COMPATIBLE INPUT ACCELERATION RECORDS



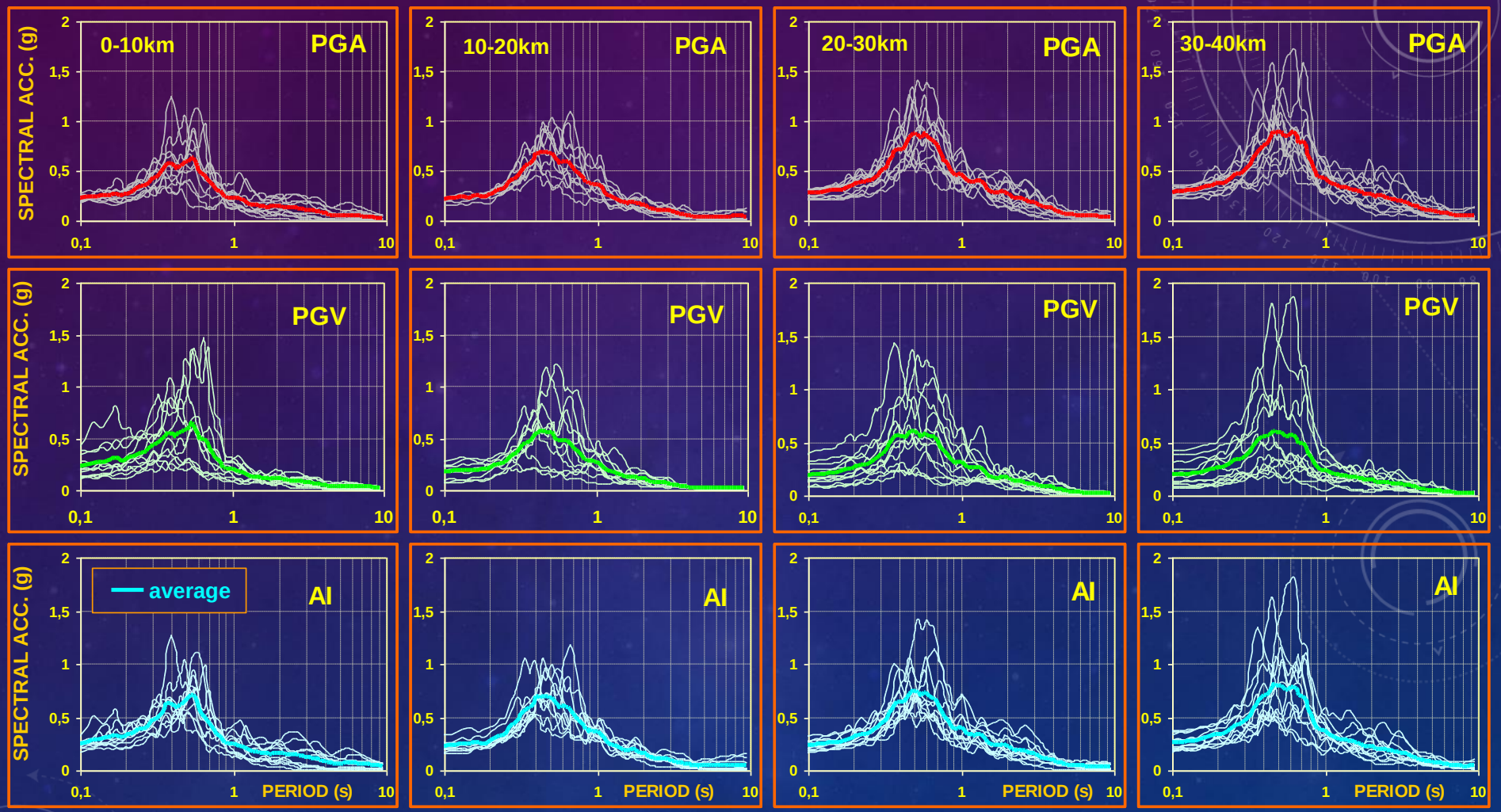
SITE RESPONSE ON THE GROUND SURFACE FOR NUMBER OF INPUT ACCELERATION RECORDS



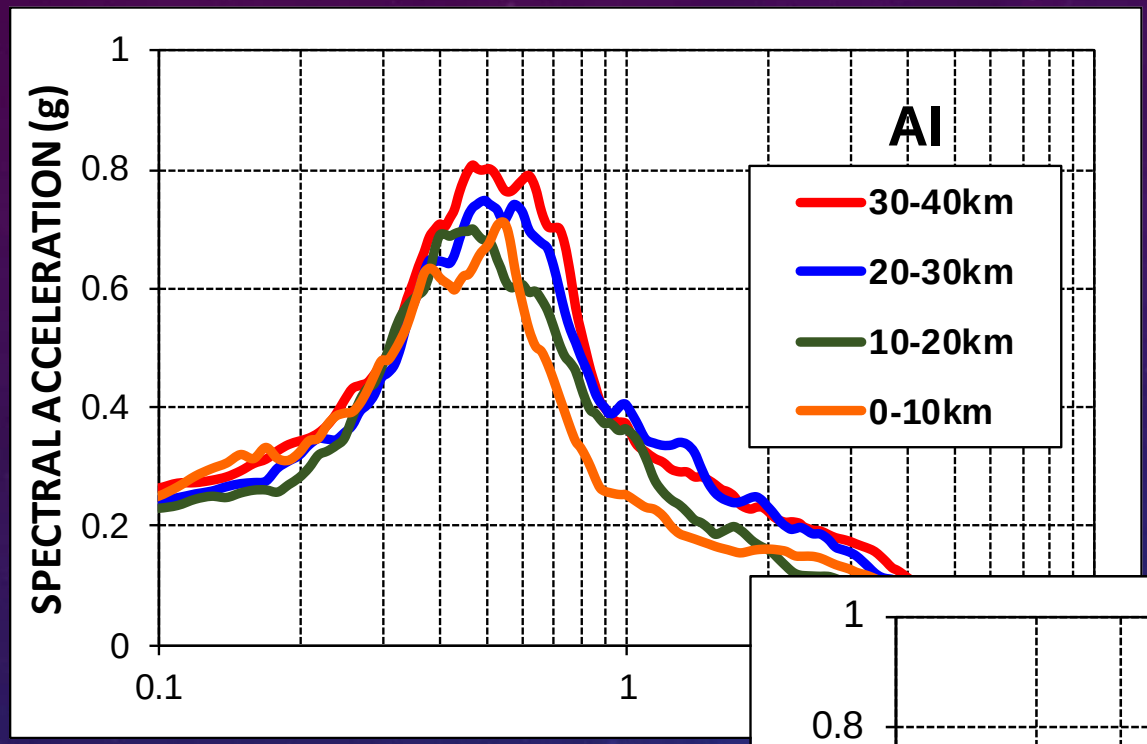
GROUND MOTION VARIABILITY - PGA SCALED ACCELERATION RECORDS

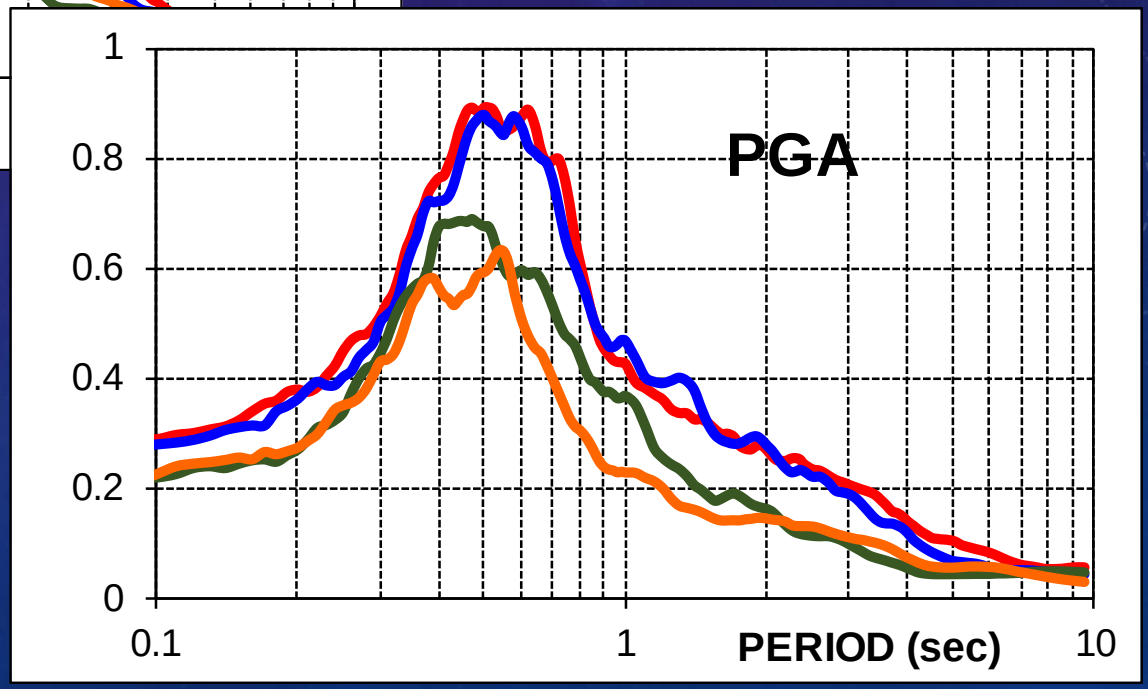


EFFECT OF SCALING SCHEME AND FAULT DISTANCE

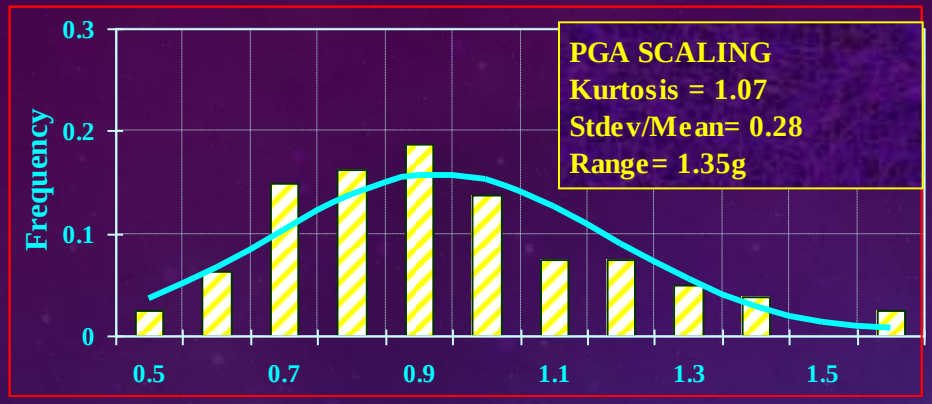


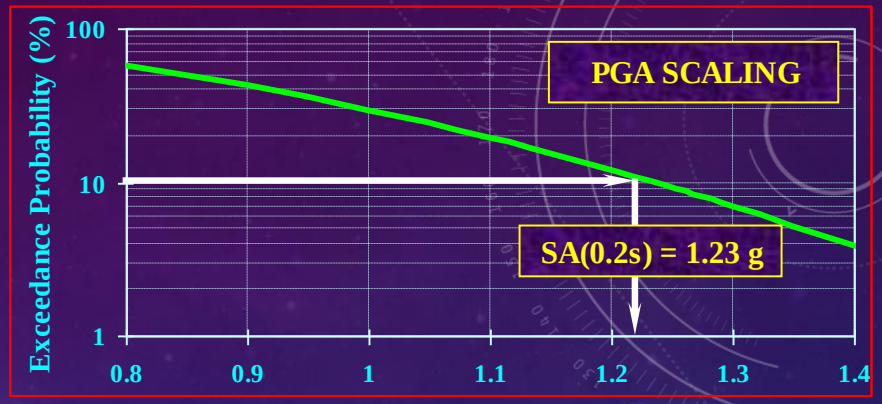
DISTANCE EFFECT

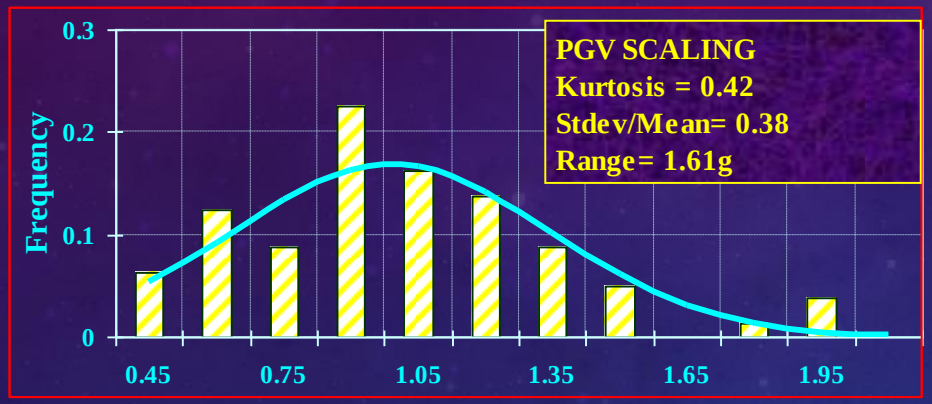


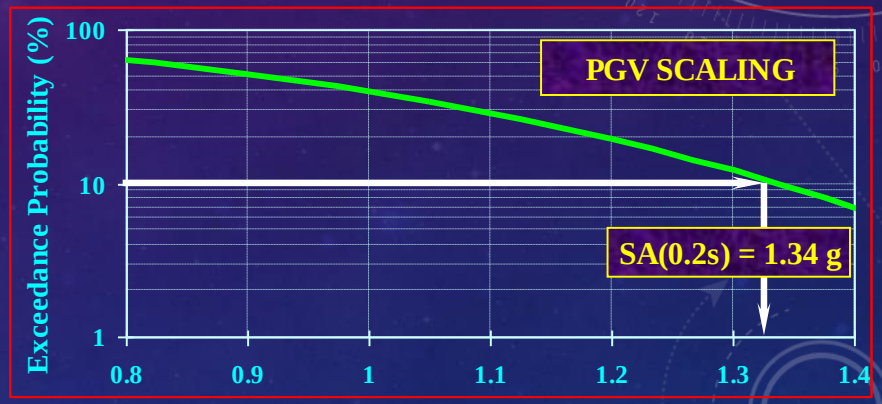


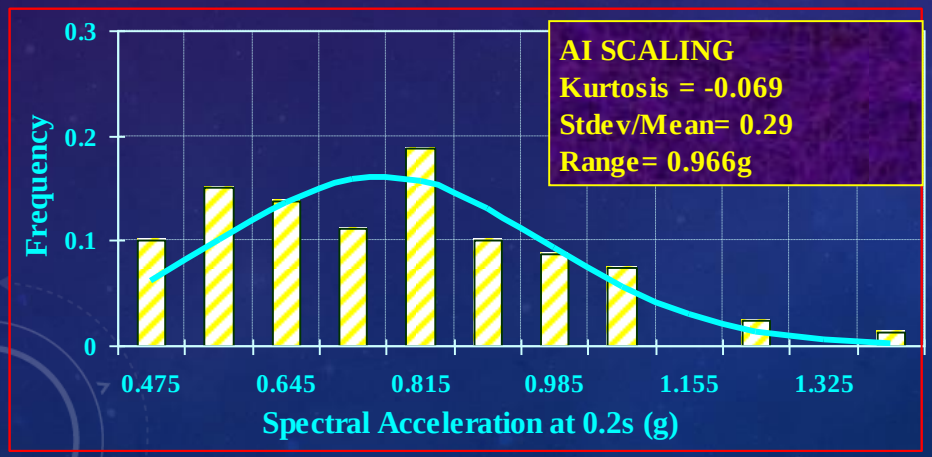
EFFECT OF SCALING PARAMETER ON SA(0.2s) ON SOIL SURFACE

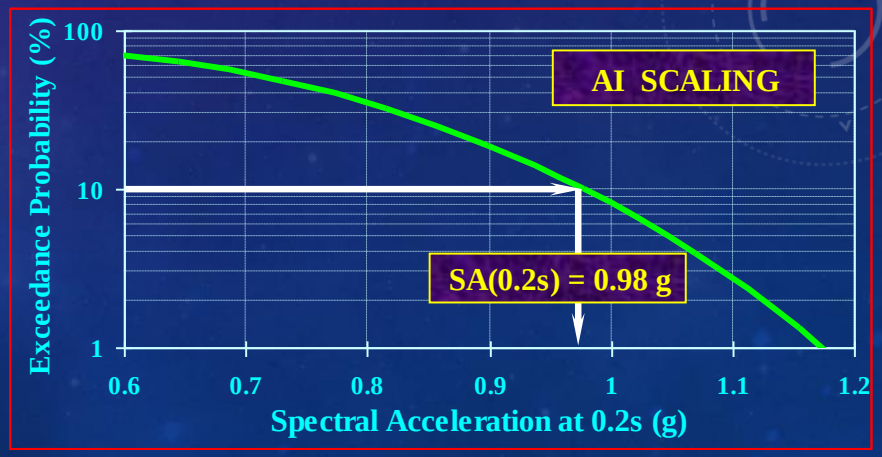




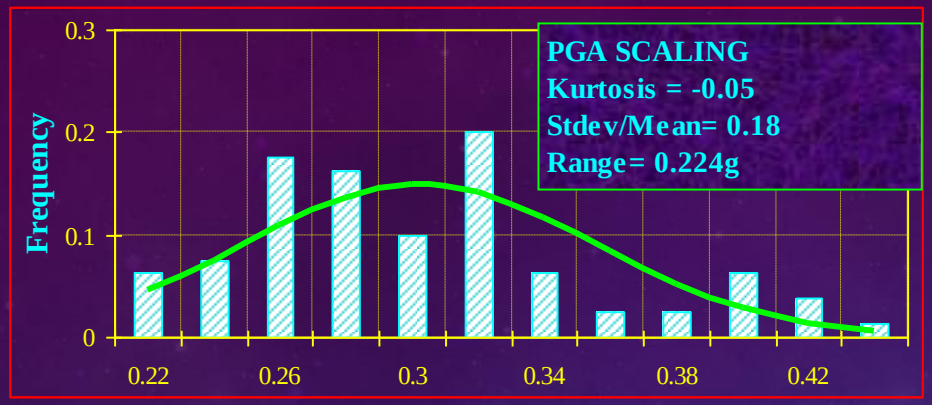


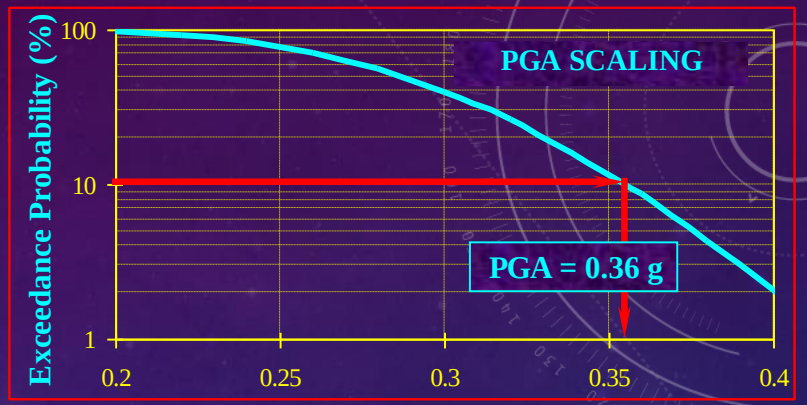


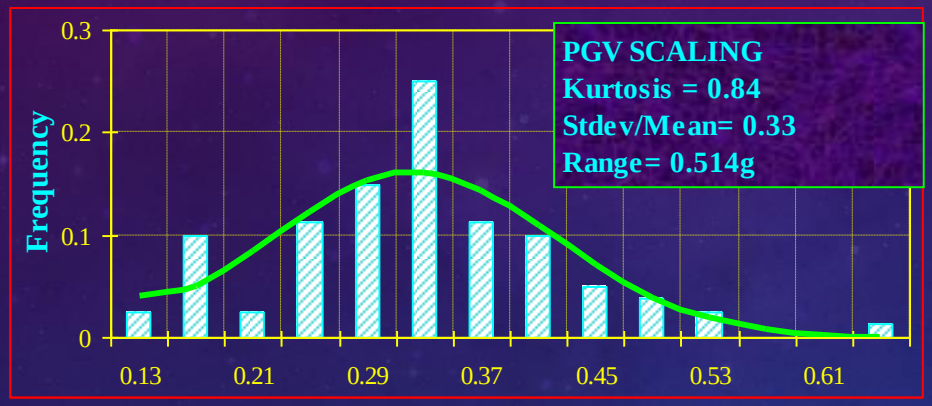


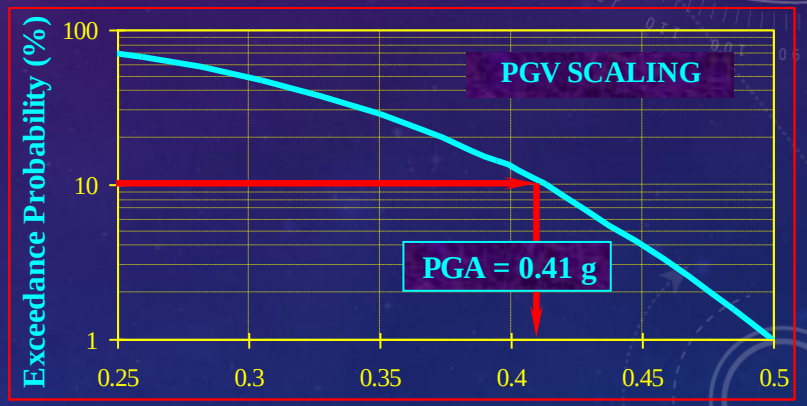


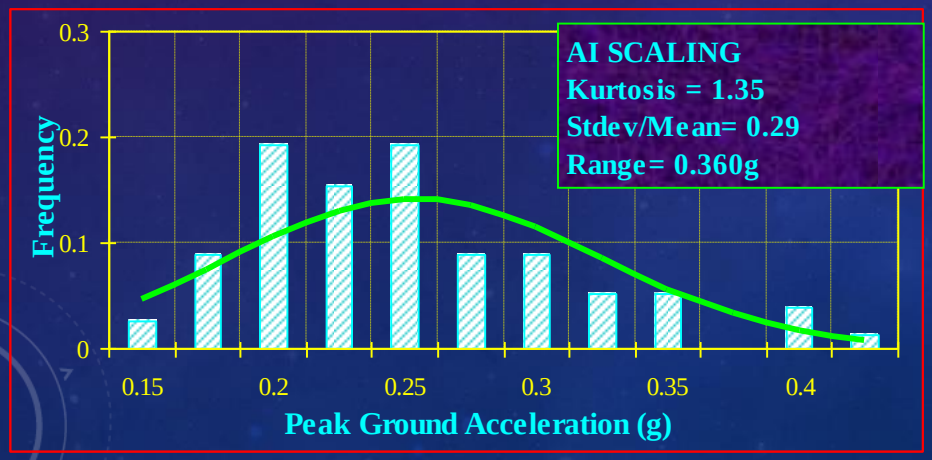
EFFECT OF SCALING PARAMETER ON PGA ON THE SOIL SURFACE

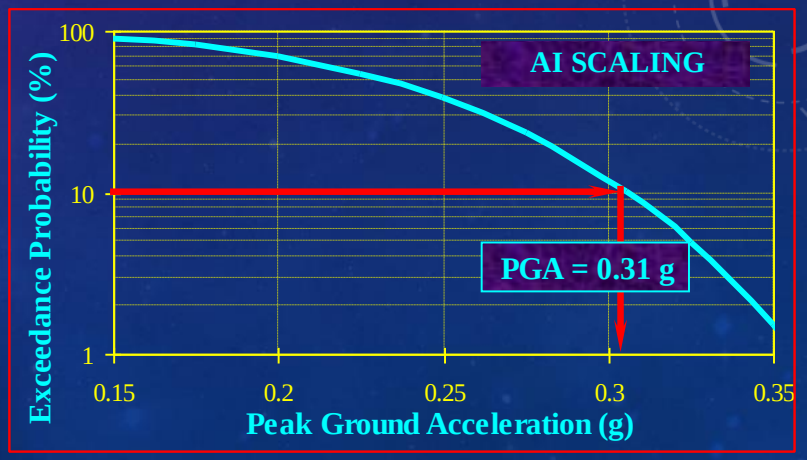








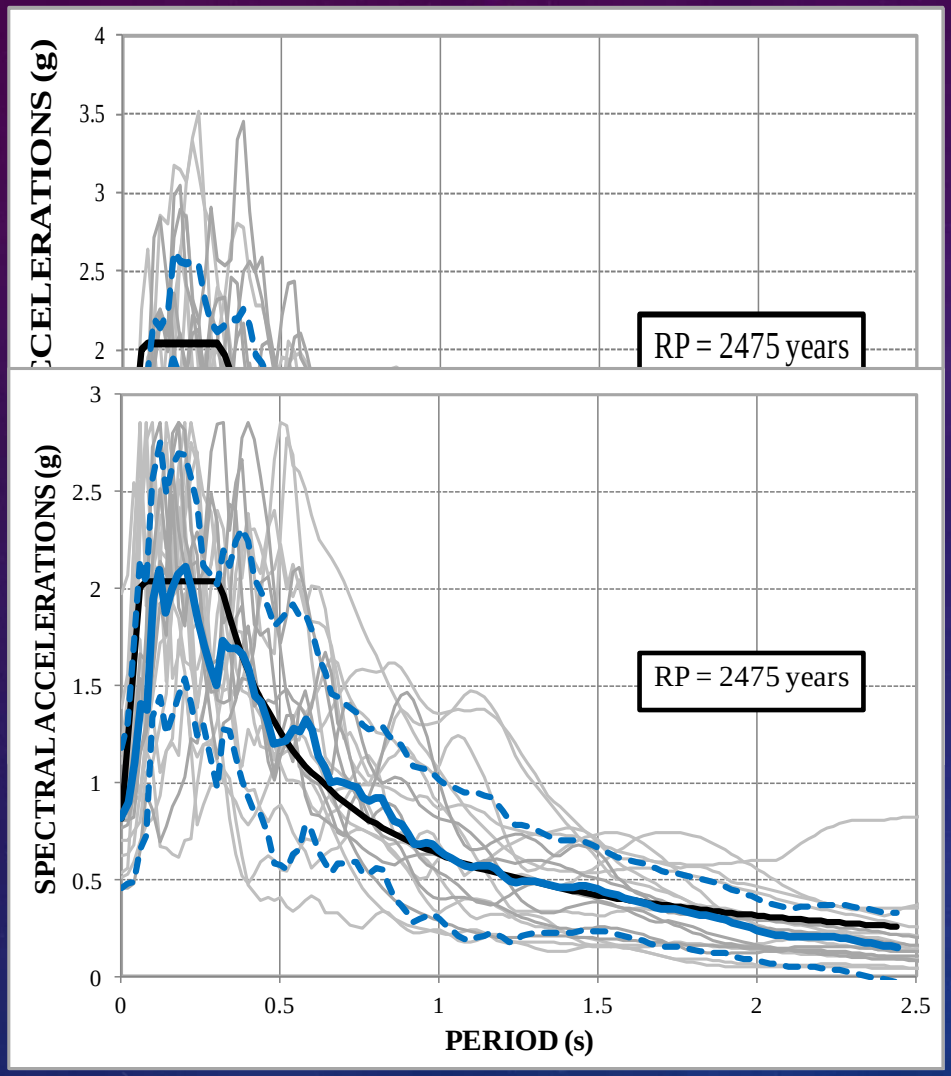


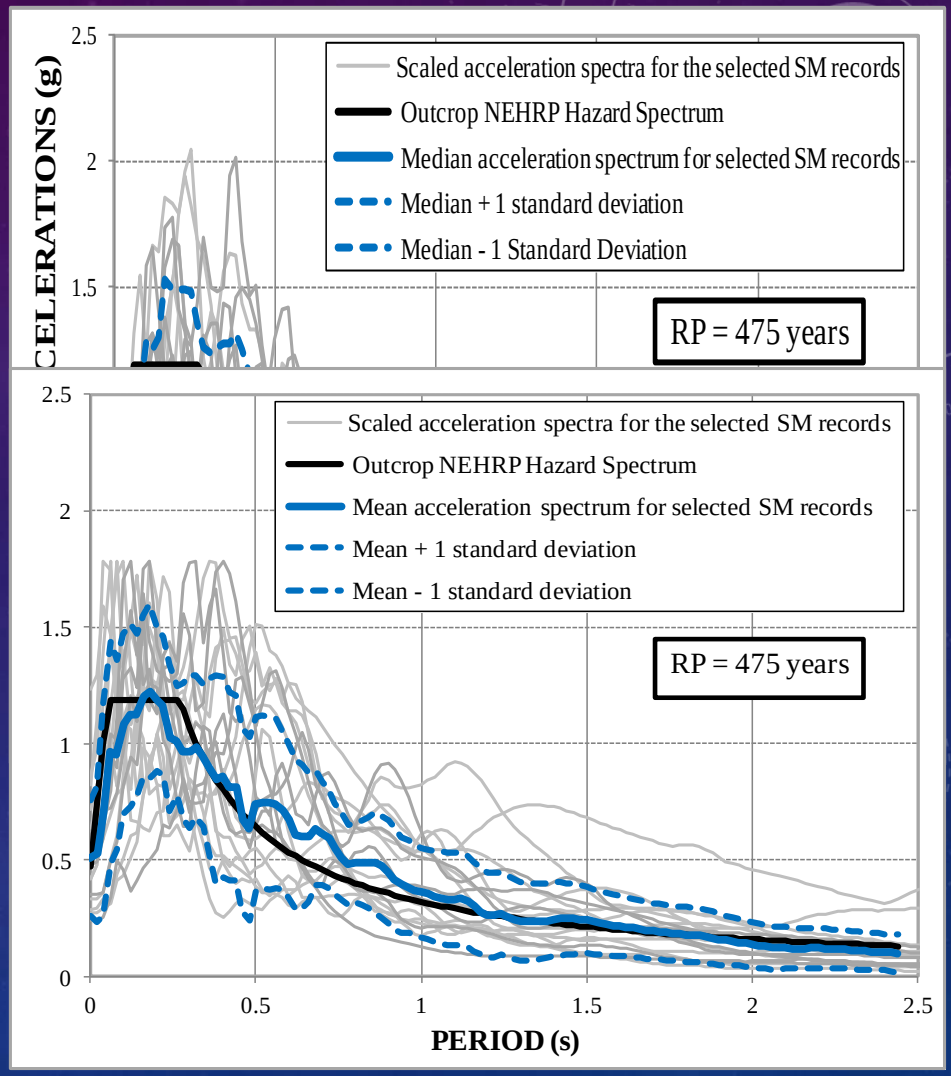


SELECTION AND SCALING INPUT GROUND MOTION

1. Recorded Acceleration Records compatible with probable fault type, fault distance, and magnitude
2. With similar PGA levels and similar acceleration response spectrum with calculated by the probabilistic seismic hazard analysis for rock outcrop
3. PGA scaling, Mean spectrum matching, Spectral Scaling using RspMatch

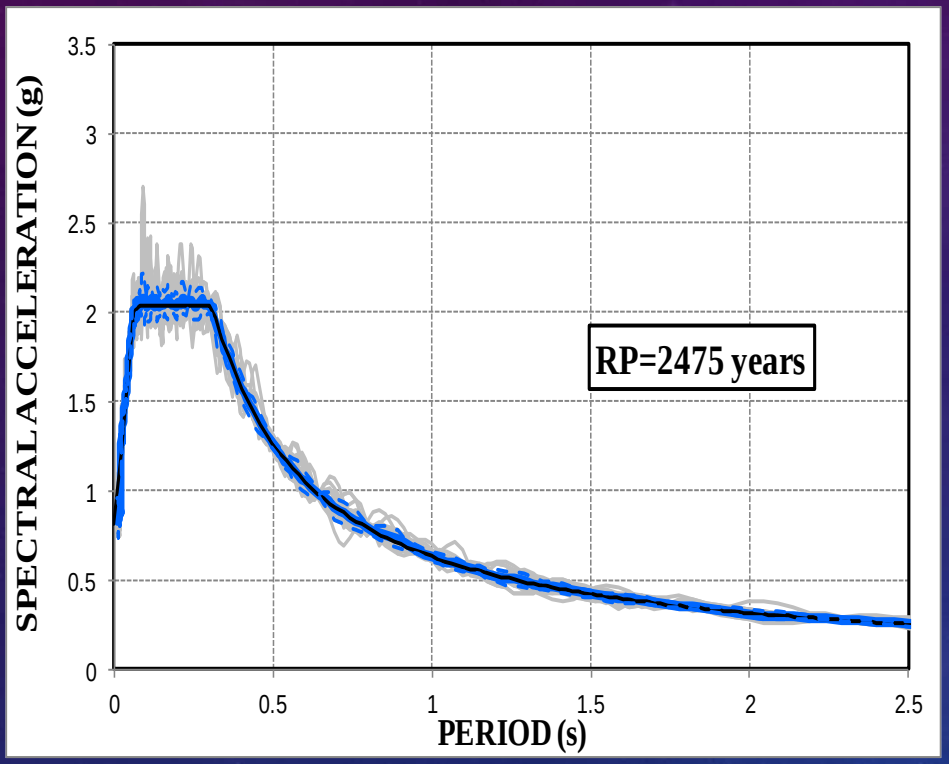
INPUT MOTION SCALING BASED ON PGA AND MEAN SPECTRUM

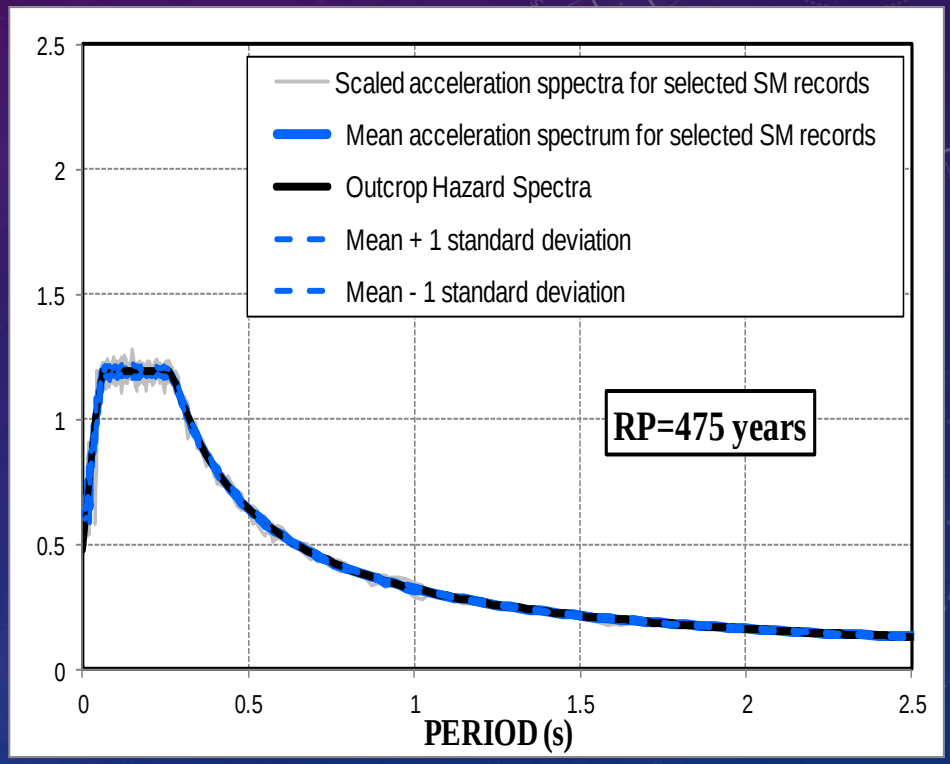




Matching by an optImization scheme modifying PGA amplitudes wIthout changing the frequency content

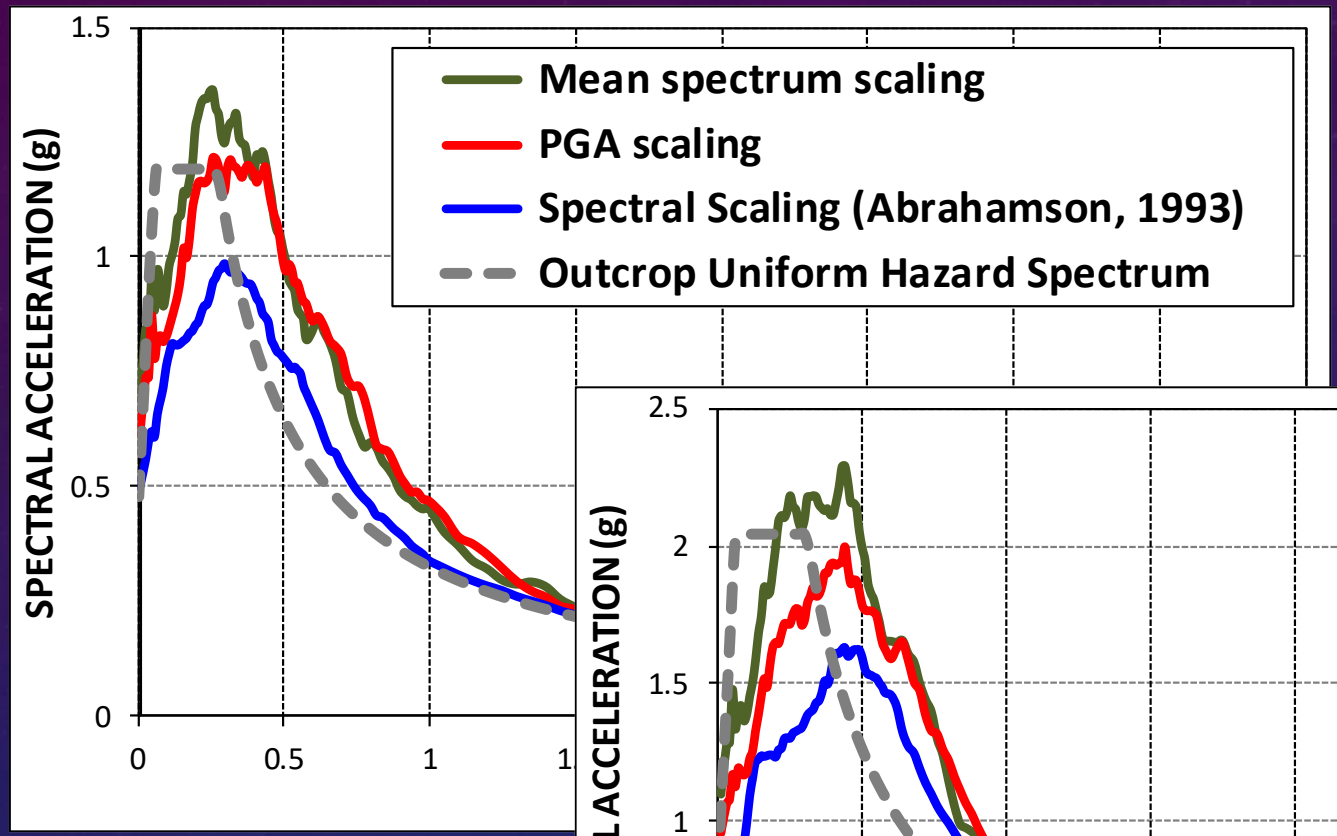
INPUT MOTION SCALING BASED SPECTRUM SCALING RSPMATCH

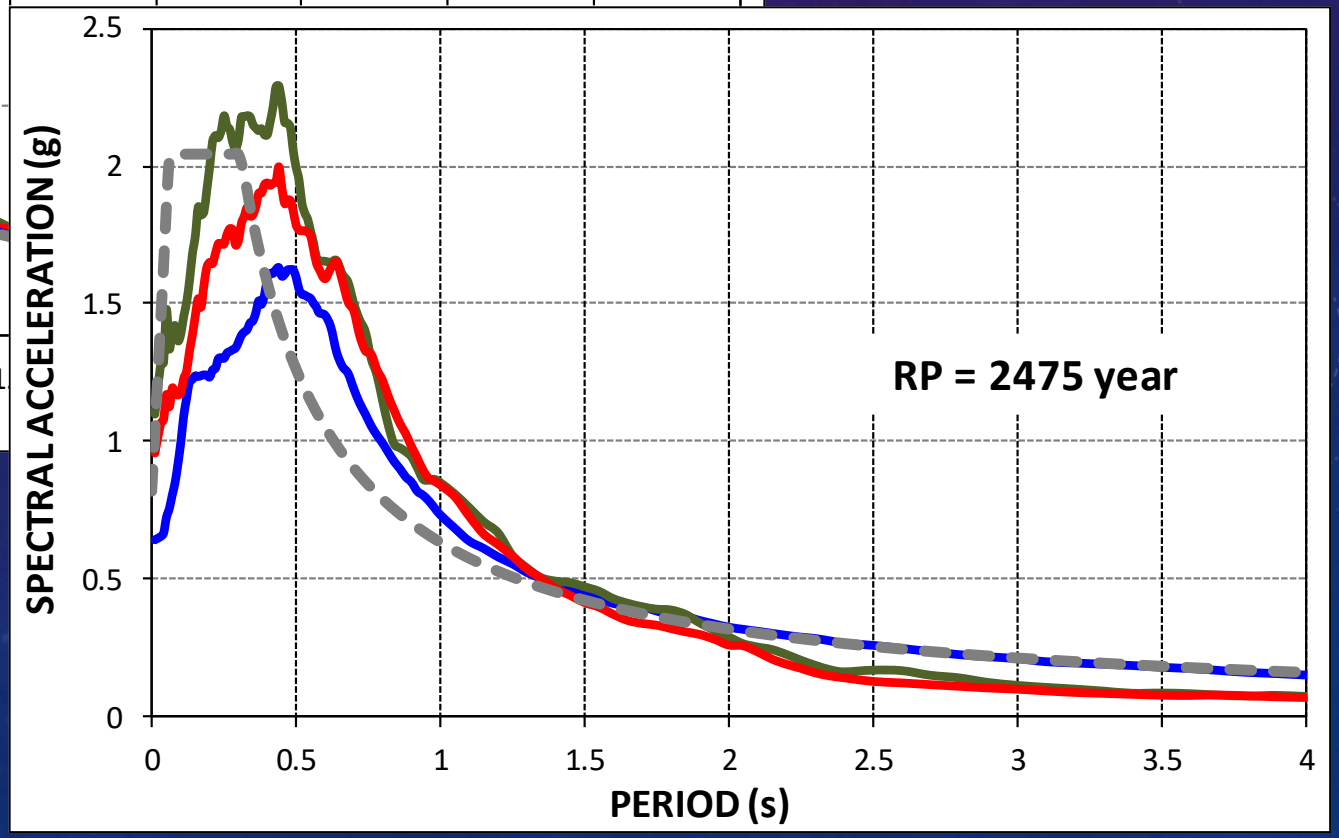




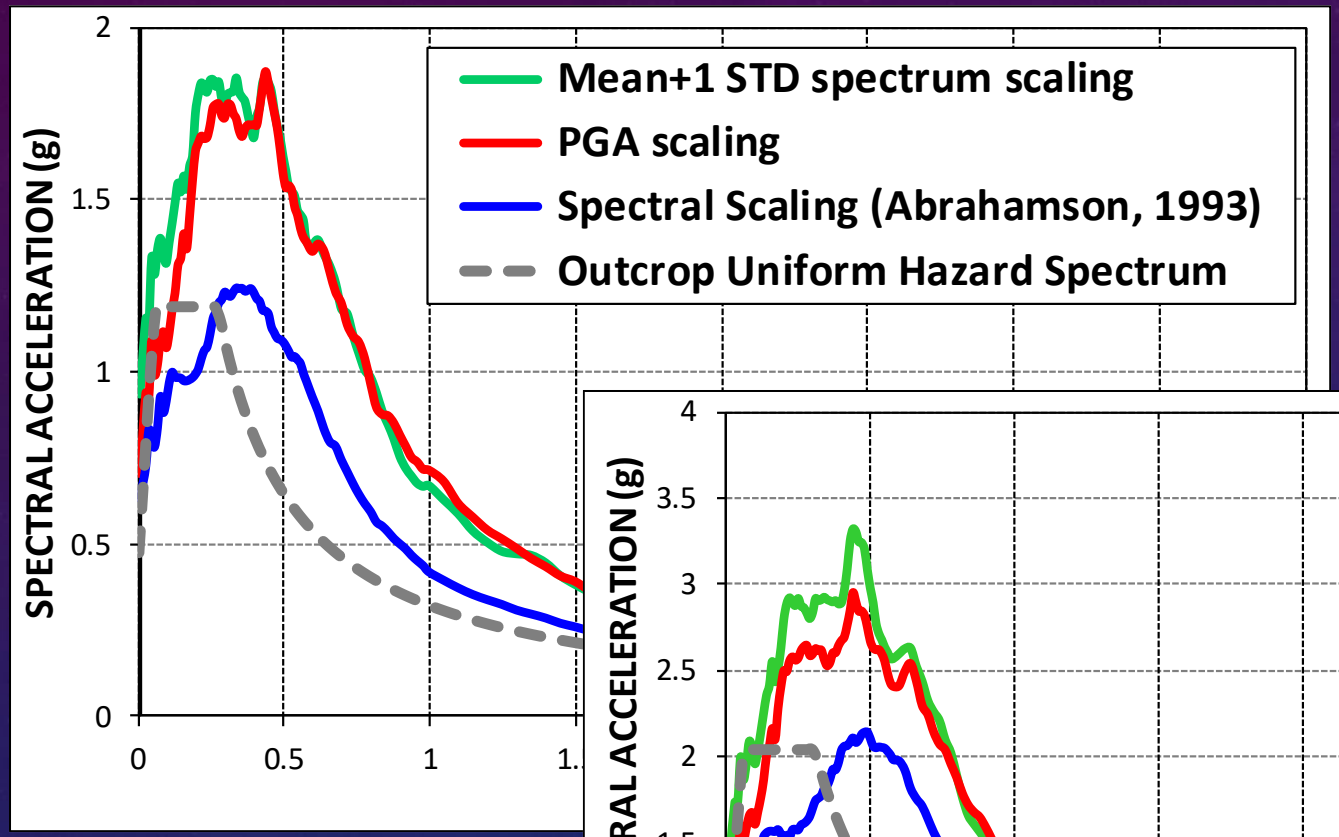
Using RspMatch suggested by Abrahamson (1992) and Hancock et al. (2006)

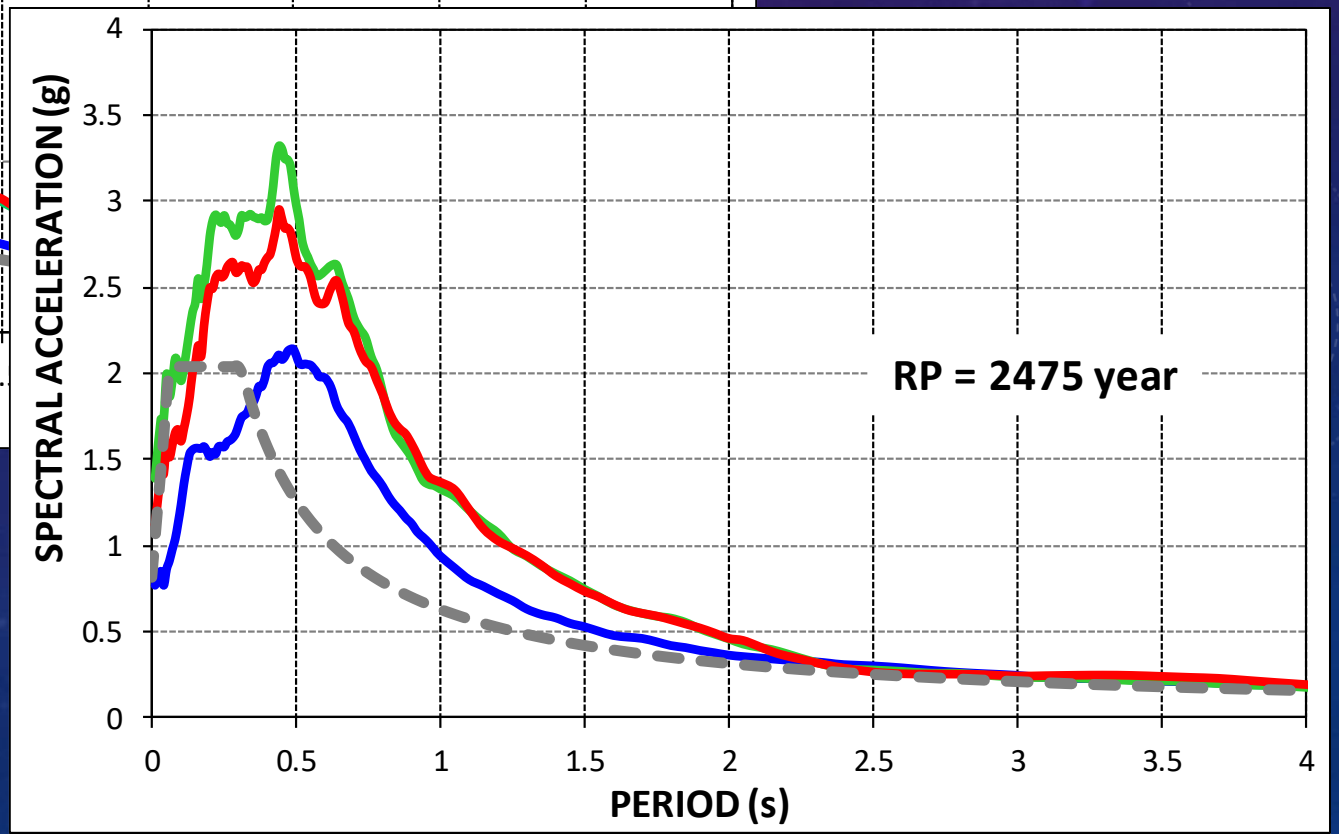
MEAN ACCELERATION SPECTRA ON THE GROUND SURFACE BASED ON SHAKE91 USING 3 DIFFERENT INPUT MOTION SCALING APPROACH



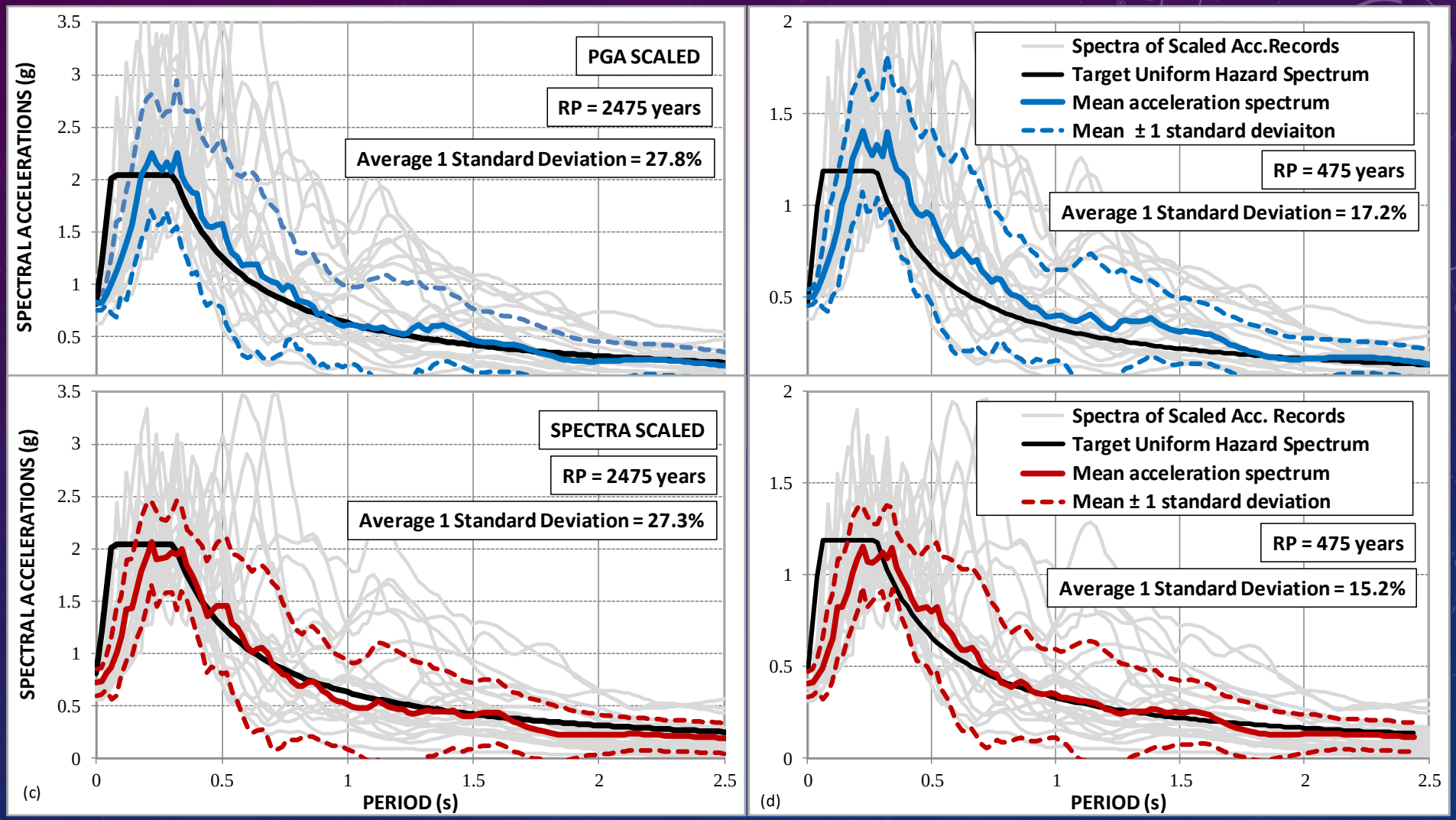


MEAN ACCELERATION + 1 STD SPECTRA ON THE GROUND SURFACE BASED ON SHAKE91 USING 3 DIFFERENT INPUT MOTION SCALING APPROACH



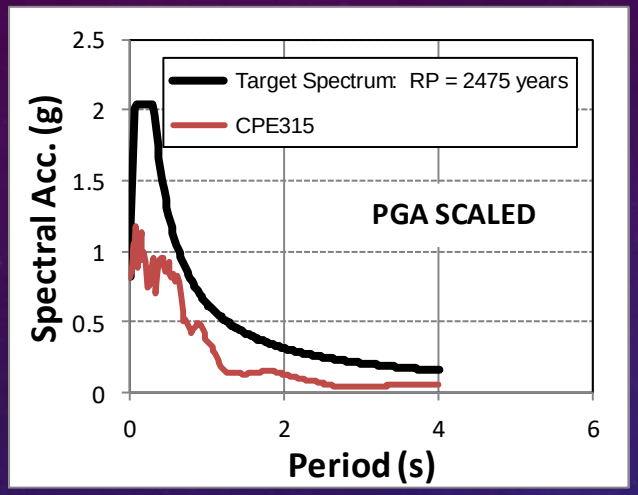


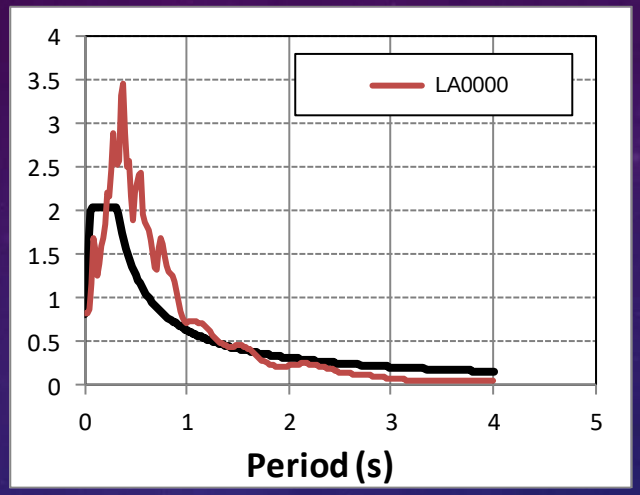
PGA AND SPECTRA SCALED INPUT ACCELERATION RECORDS

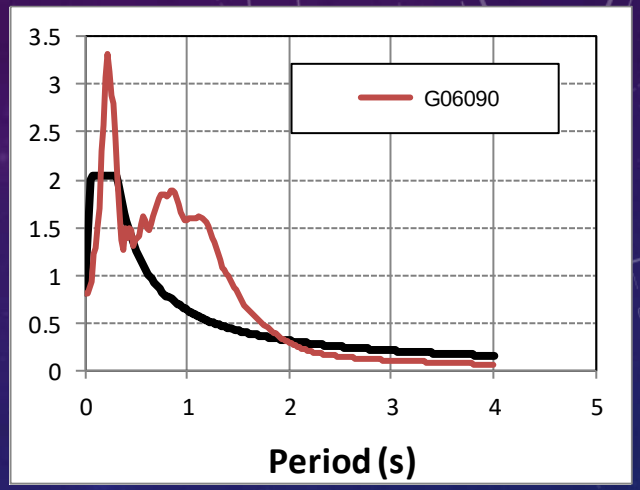


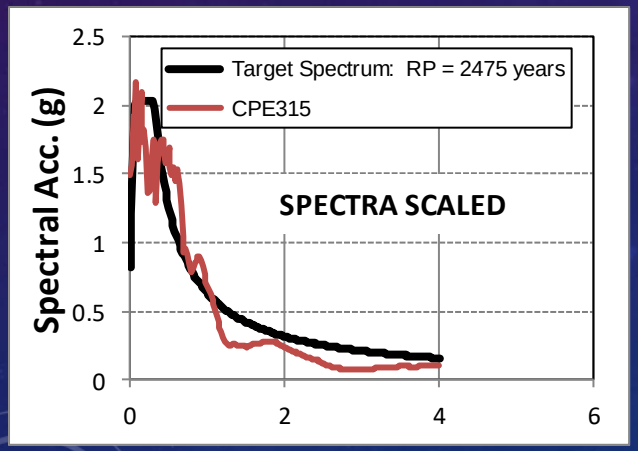
Matching by an optimization scheme for each selected earthquake record with respect to target acceleration spectra on the engineering bedrock

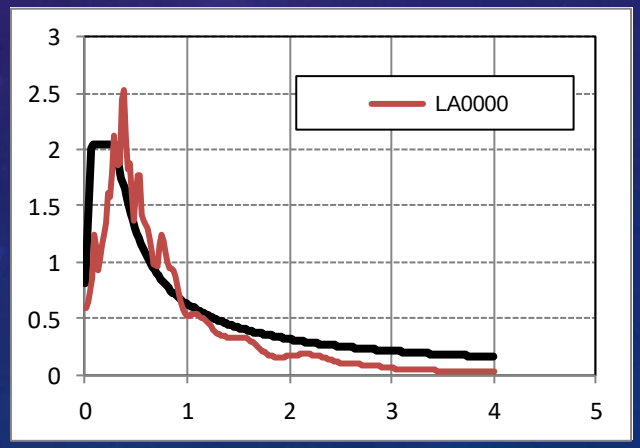
COMPARISON OF SCALING PROCEDURES

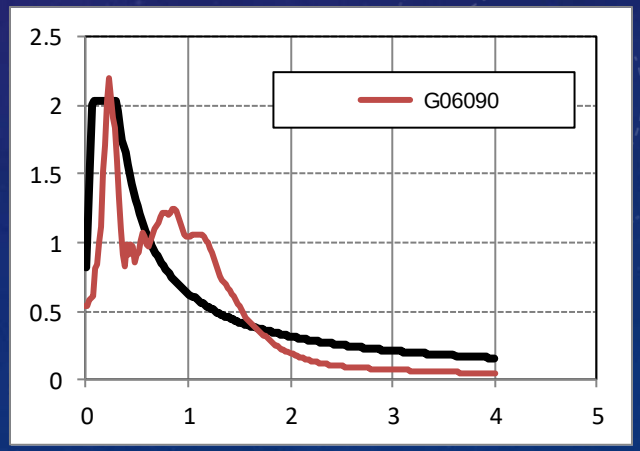




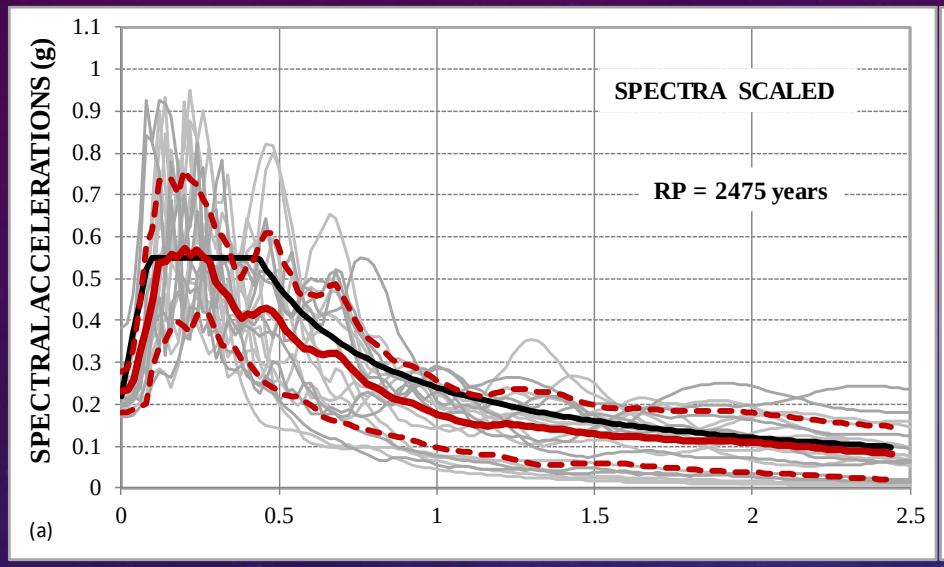


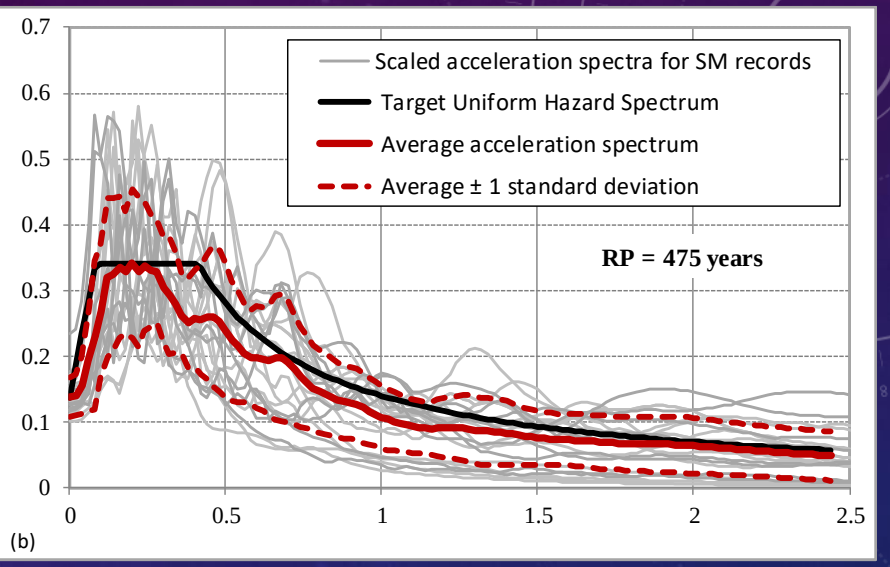


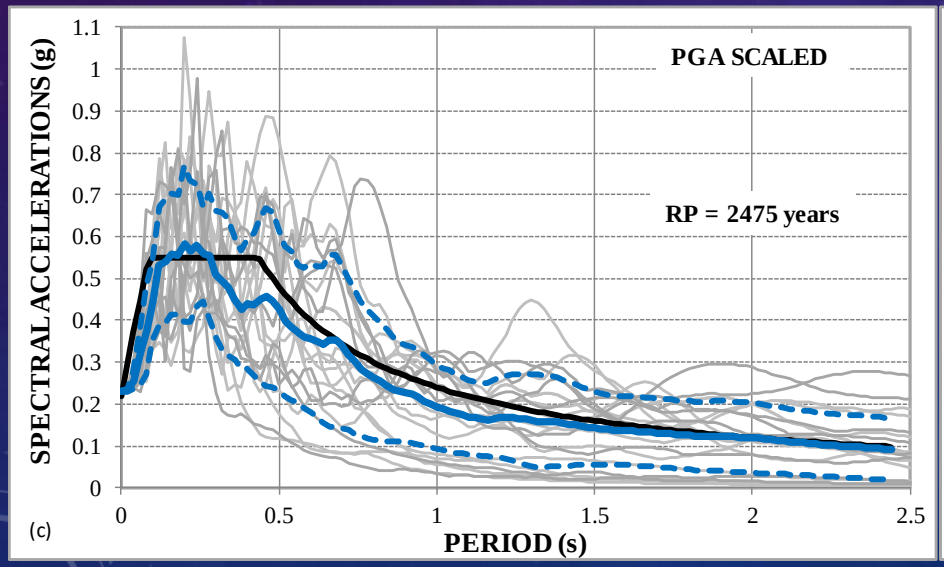


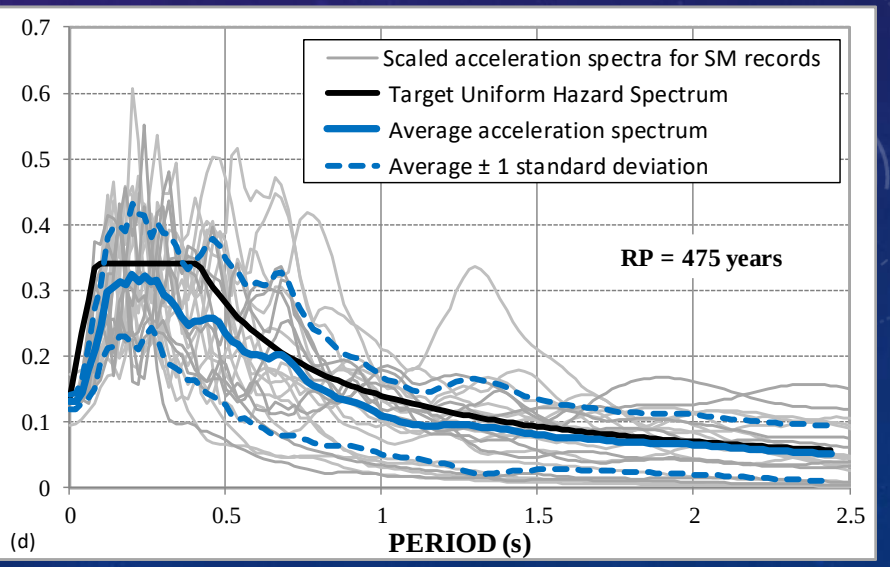


PGA AND SPECTRA SCALED INPUT ACCELERATION RECORDS

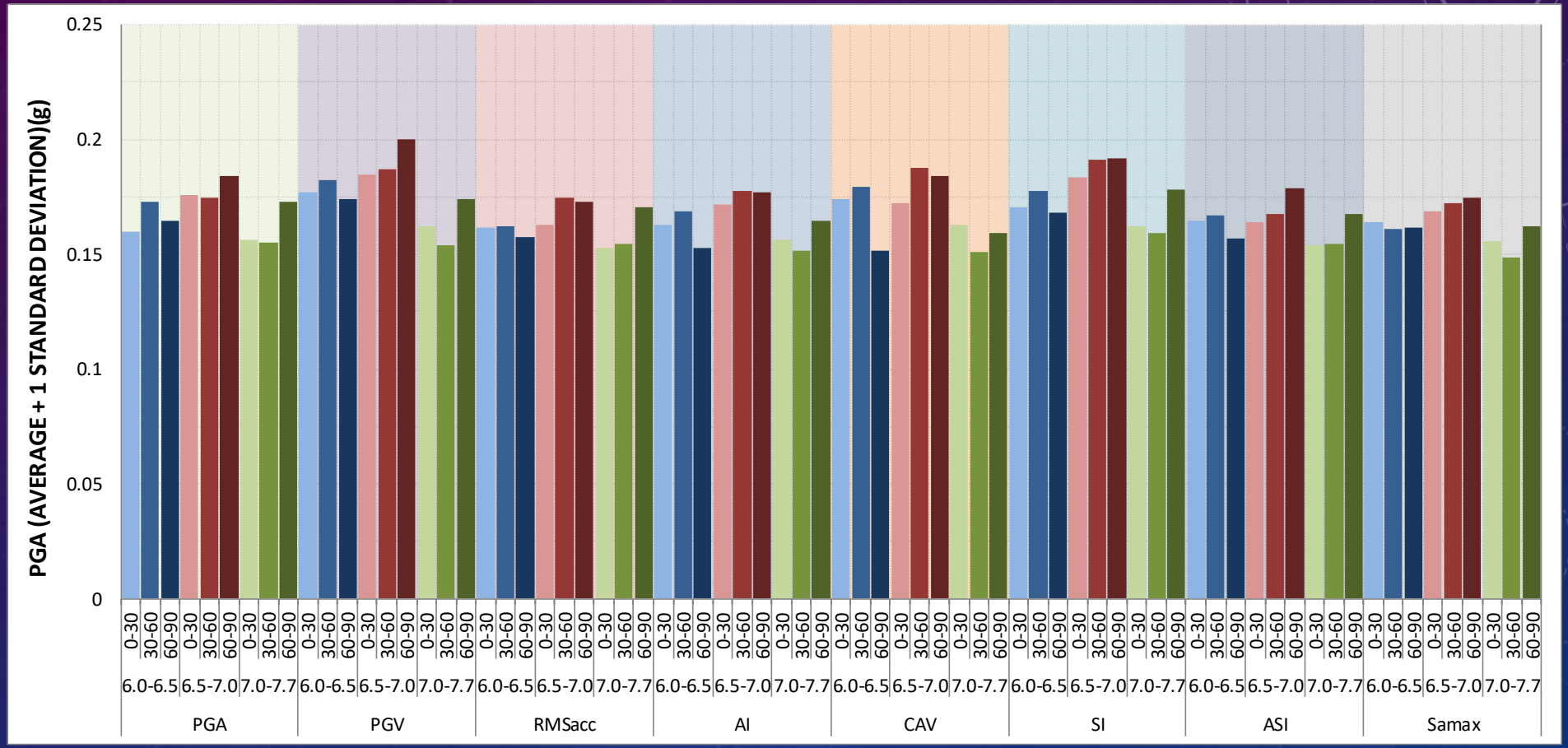






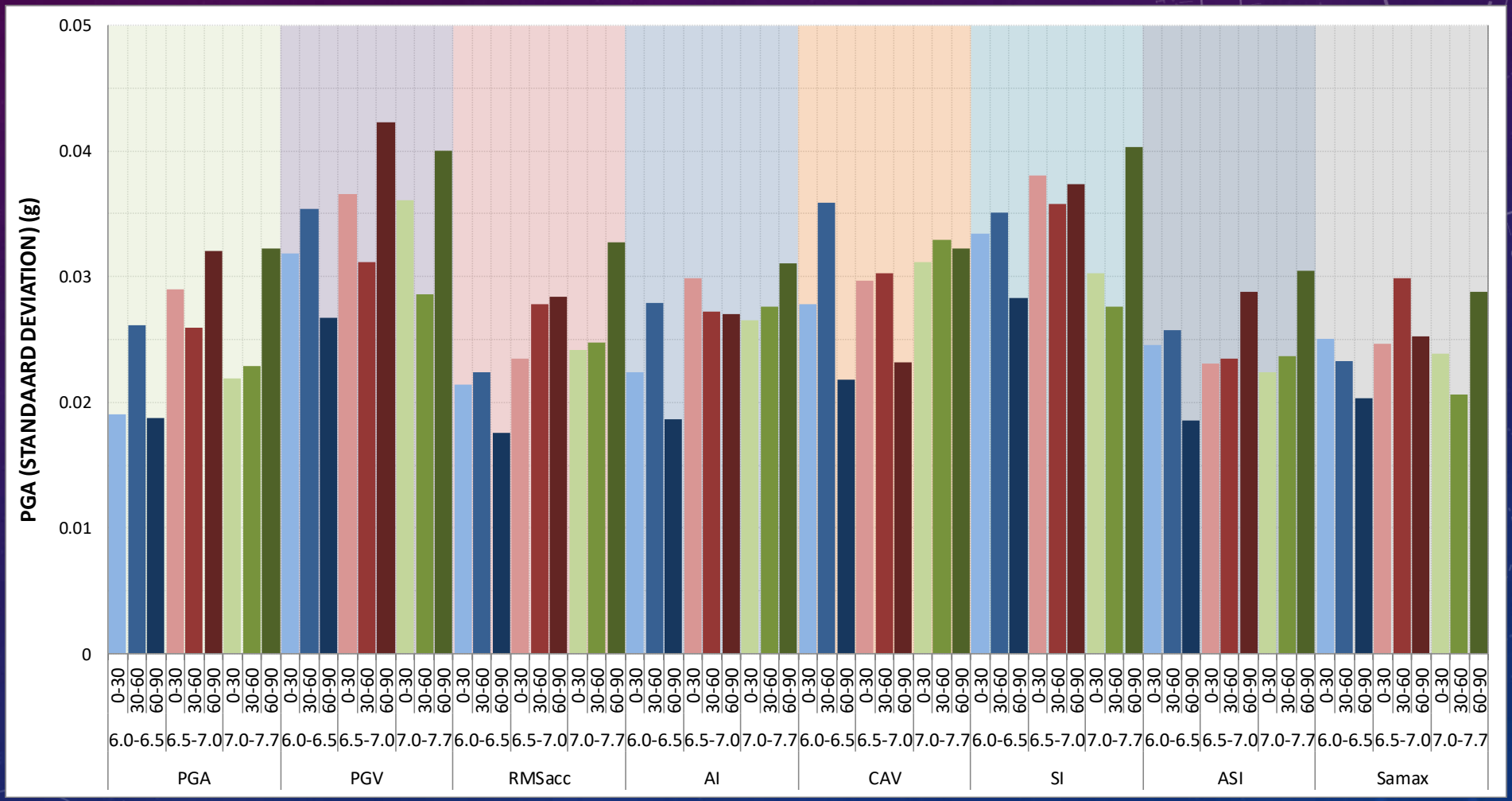


SCALING OF ACCELERATION RECORDS FOR DIFFERENT PARAMETERS WRT MAGNITUDE AND DISTANCE RANGES



Max= 0.20g Min= 0.149g Average= 0.168g

SCALING OF ACCELERATION RECORDS FOR DIFFERENT PARAMETERS WRT MAGNITUDE AND DISTANCE RANGES



Max= 0.042g Min= 0.018g Average= 0.028g

SITE CHARACTERIZATION

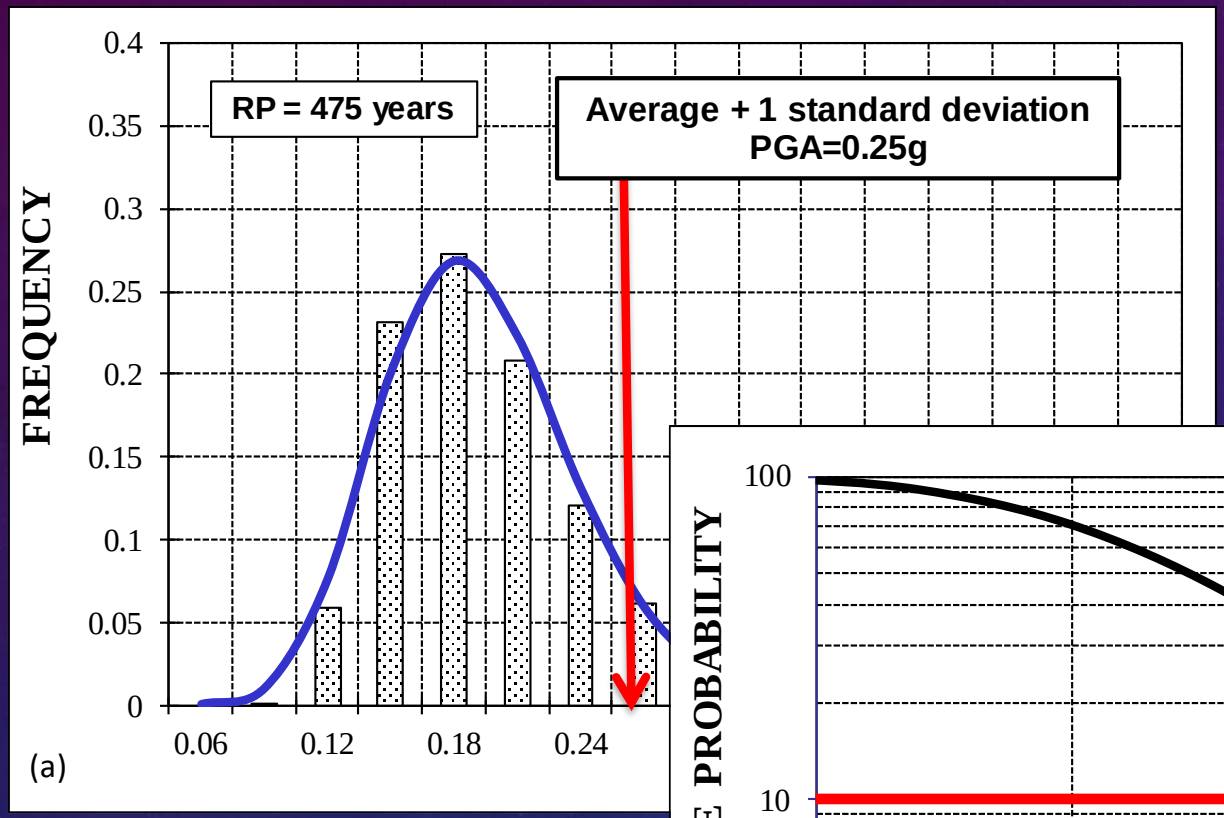
Site with 25 soil profiles where the variation of shear wave velocities with depth are estimated based on

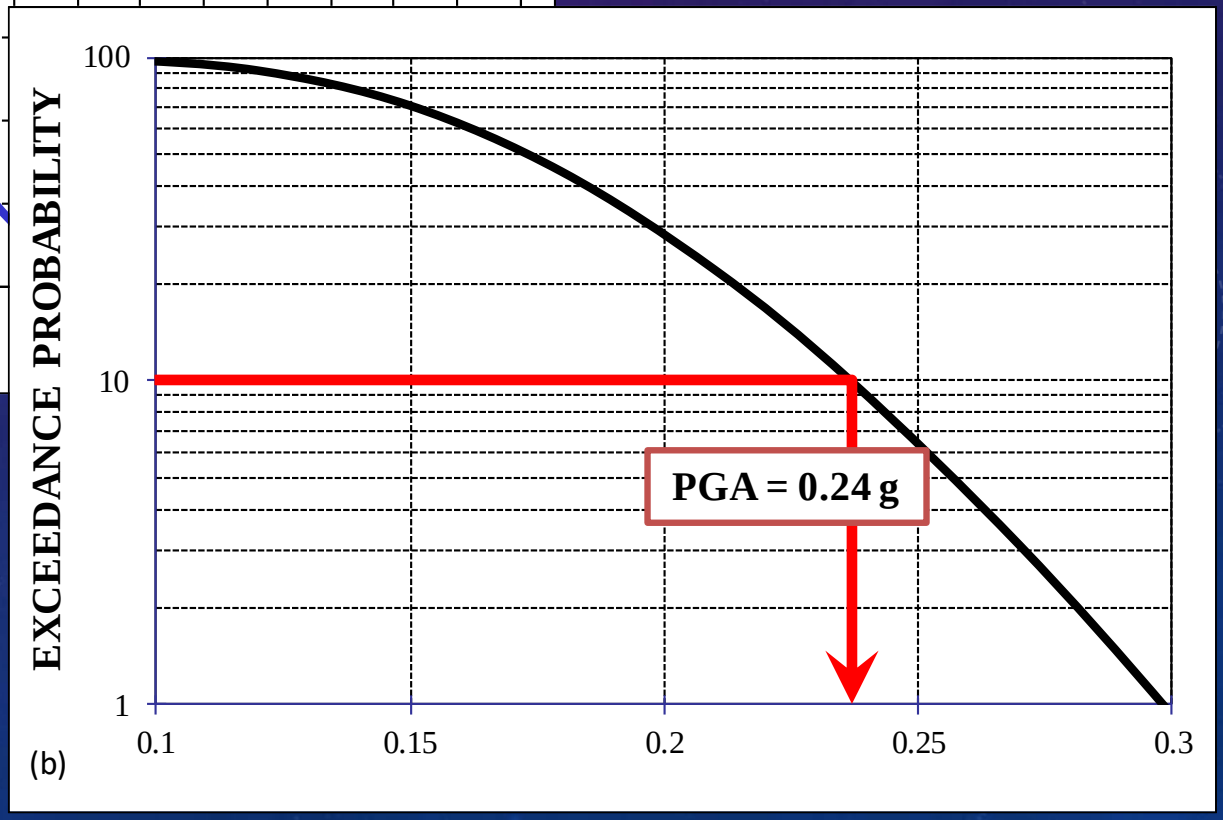
1. down hole seismic wave velocity measurements,
2. in-hole seismic wave velocity measurements,
3. seismic wave velocity based on MASW method,
4. using an empirical Vs-SPT N relationship.

SITE CHARACTERIZATION FOR SITE RESPONSE ANALYSIS

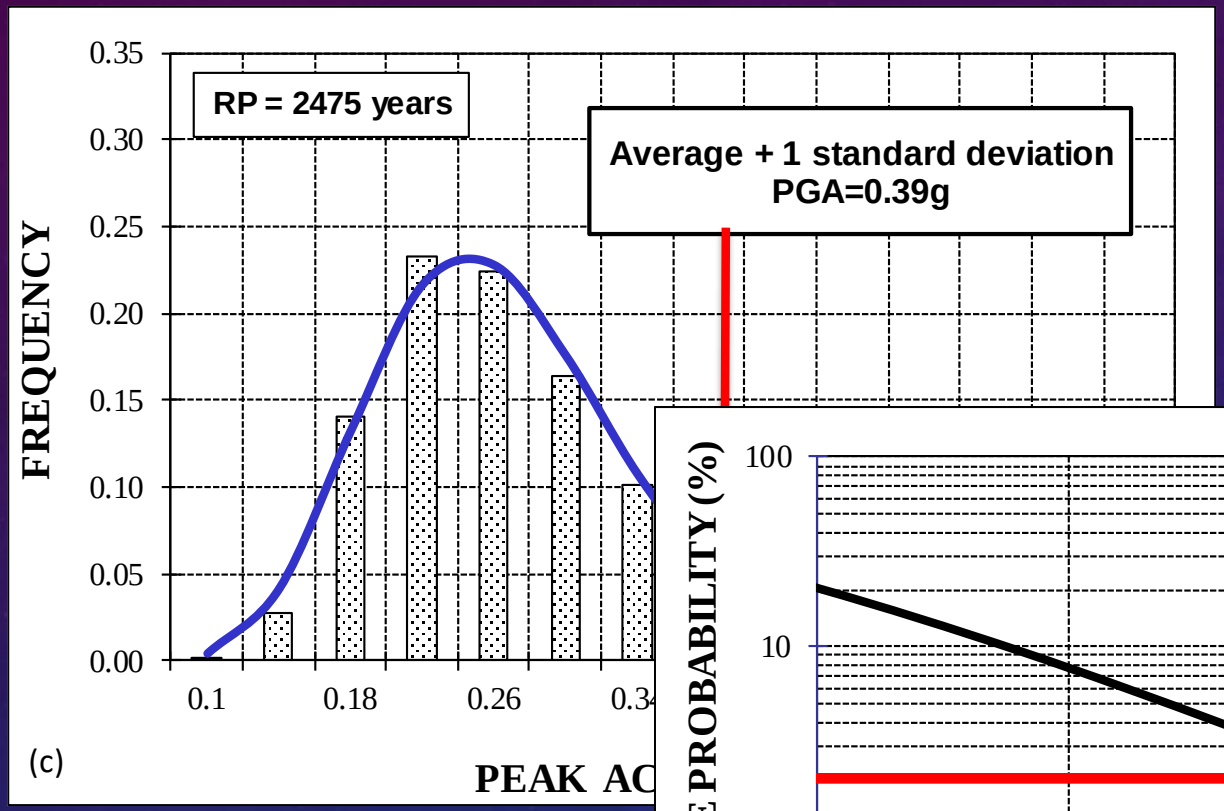
- Properties and thickness of soil layers
- Dinamic shear modulus
- Dinamic shear modulus reduction
- Depth of engineering bedrock and shear wave velocity

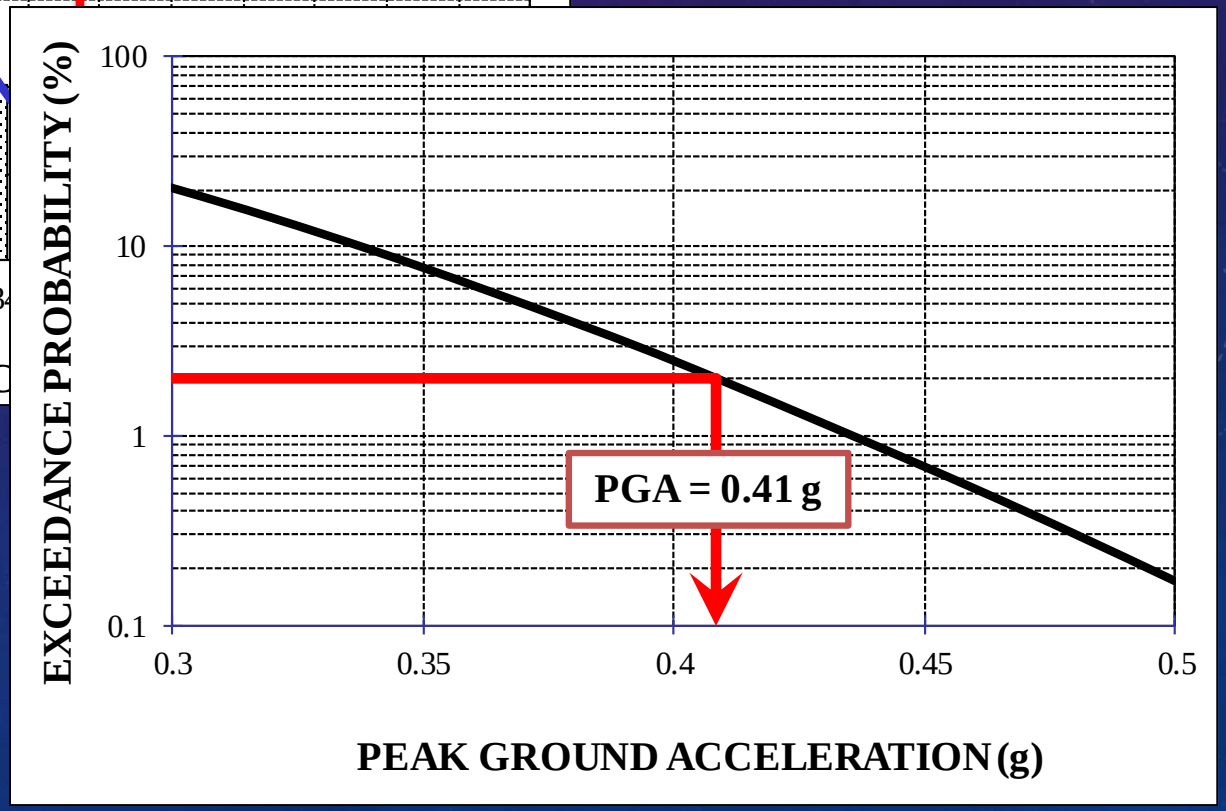
SIMPLIFIED INTERPRETATION CASE 1



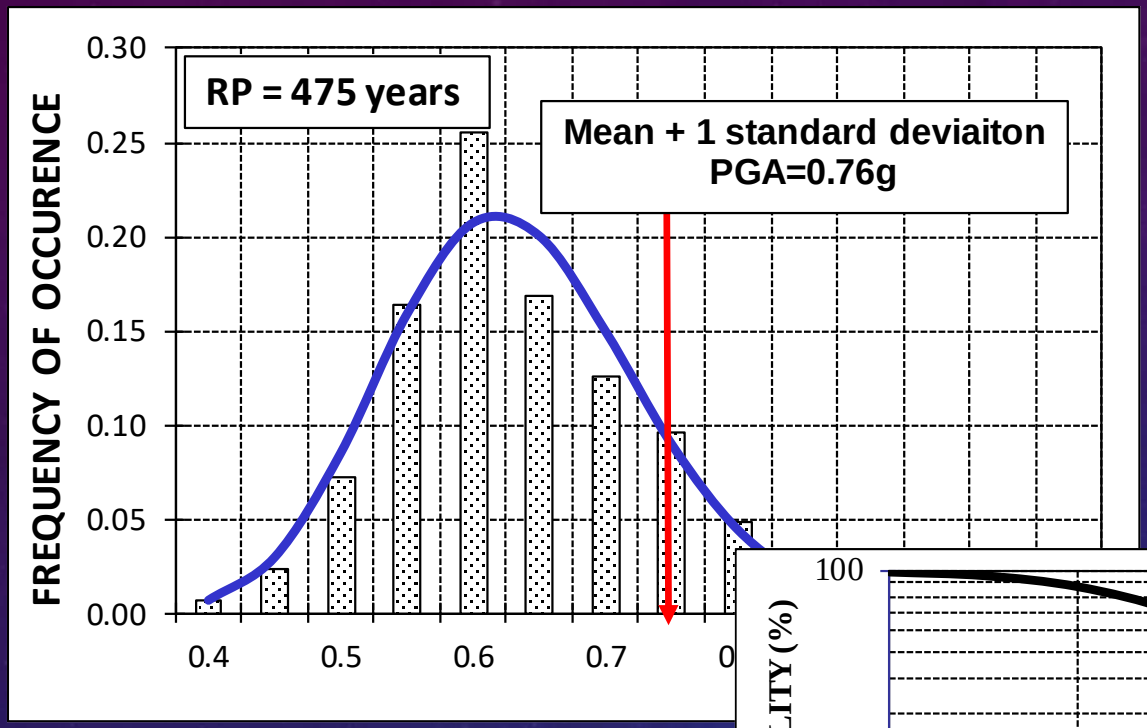


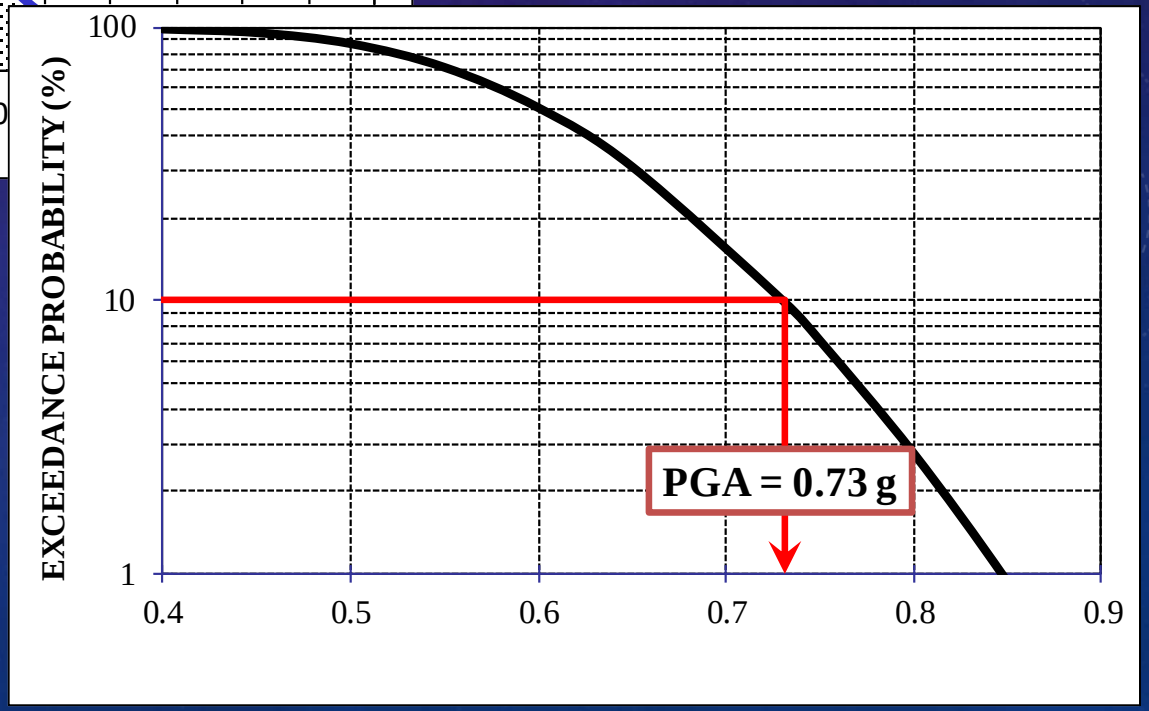
SIMPLIFIED INTERPRETATION CASE 1



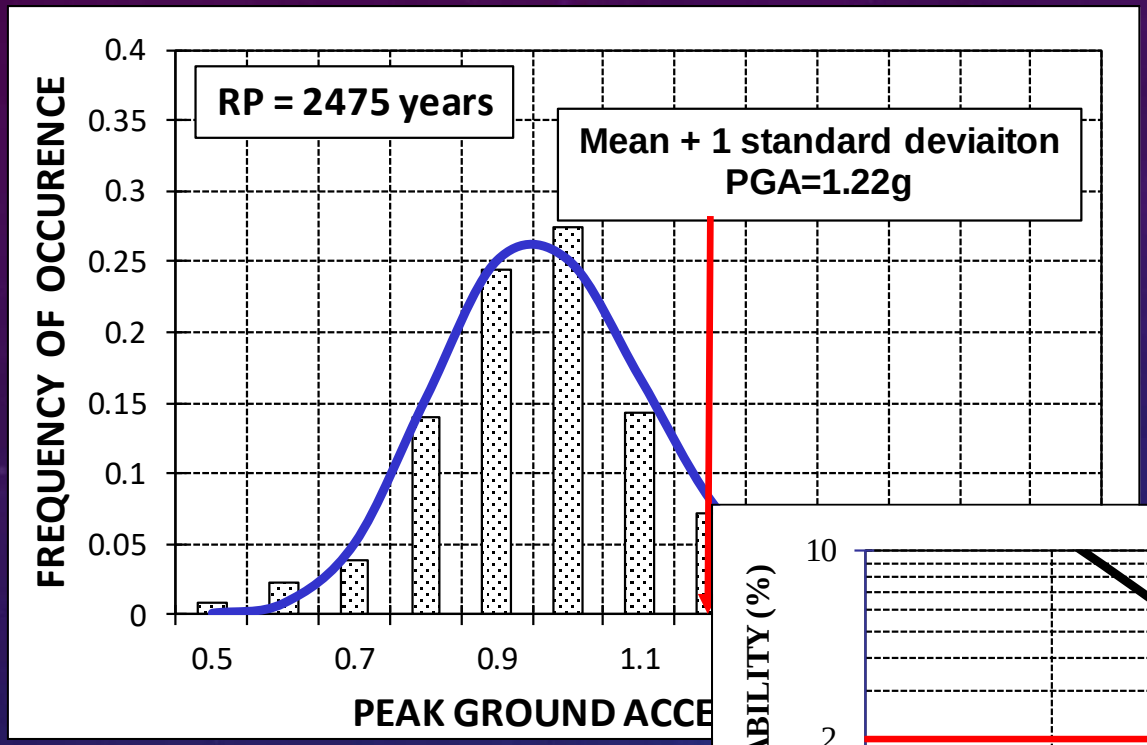


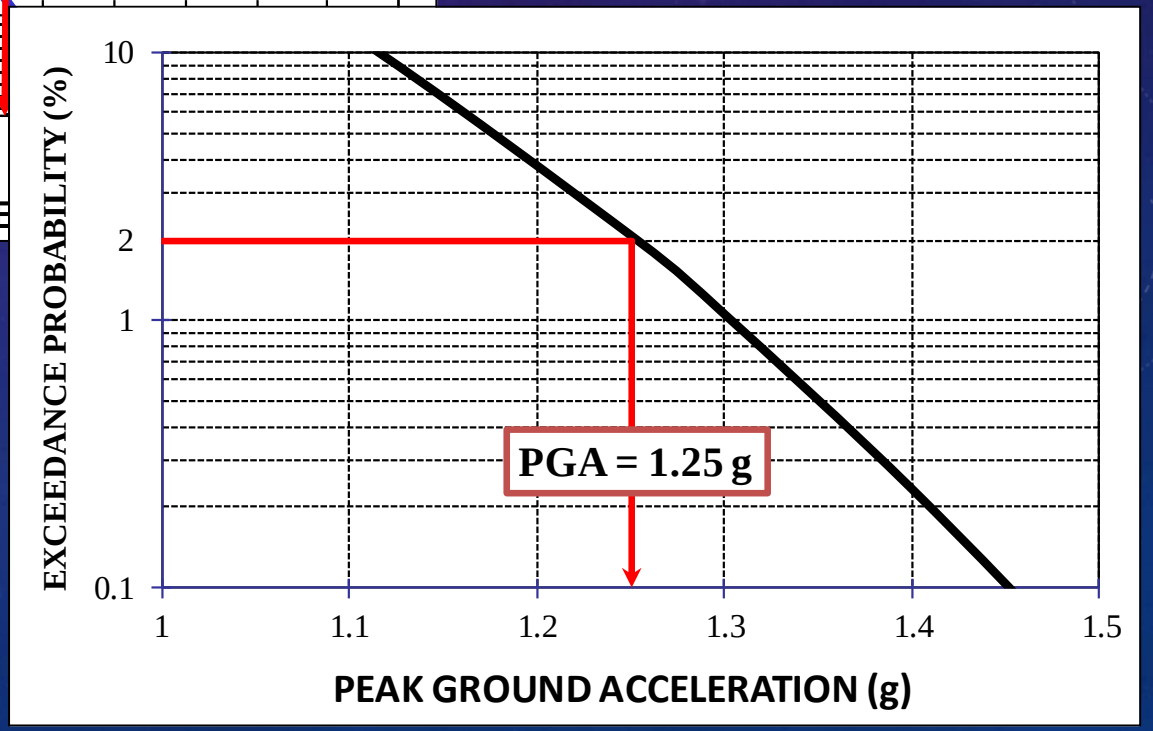
SIMPLIFIED INTERPRETATION CASE 2



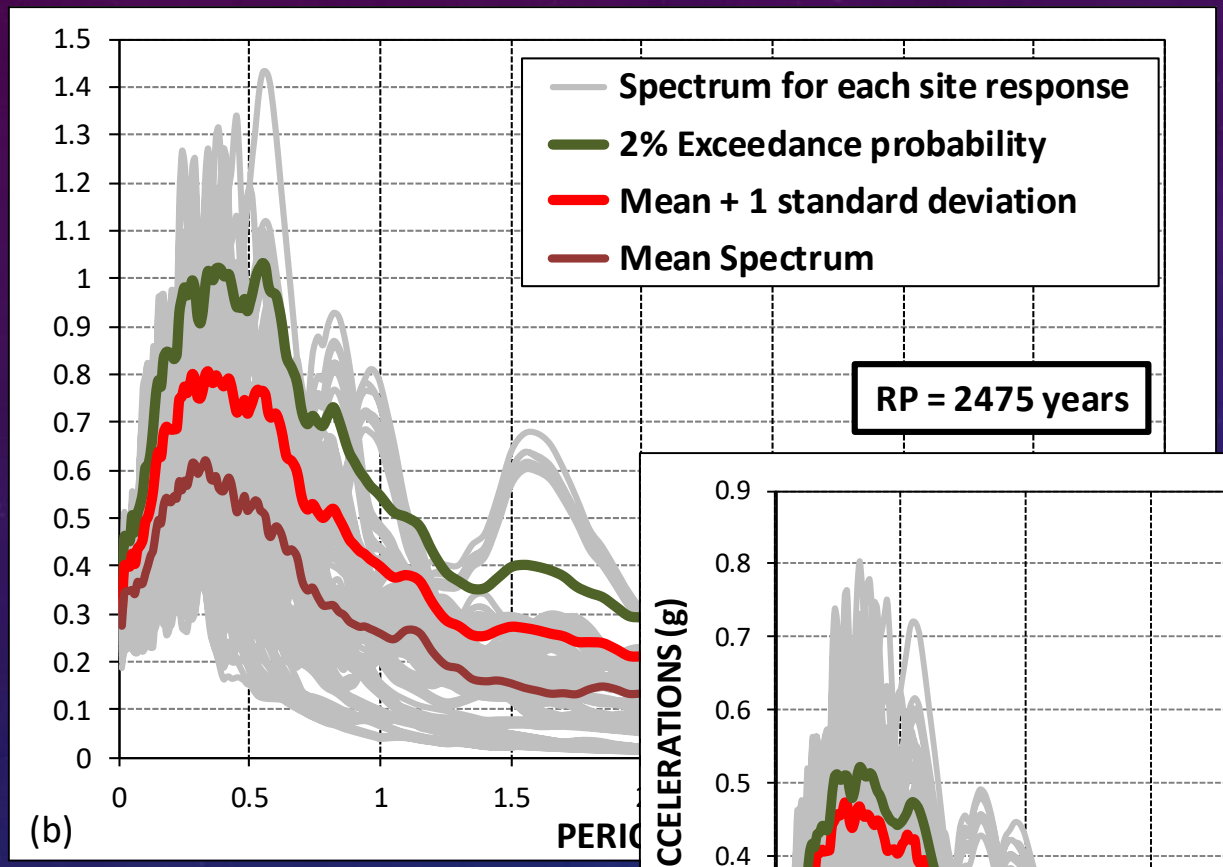


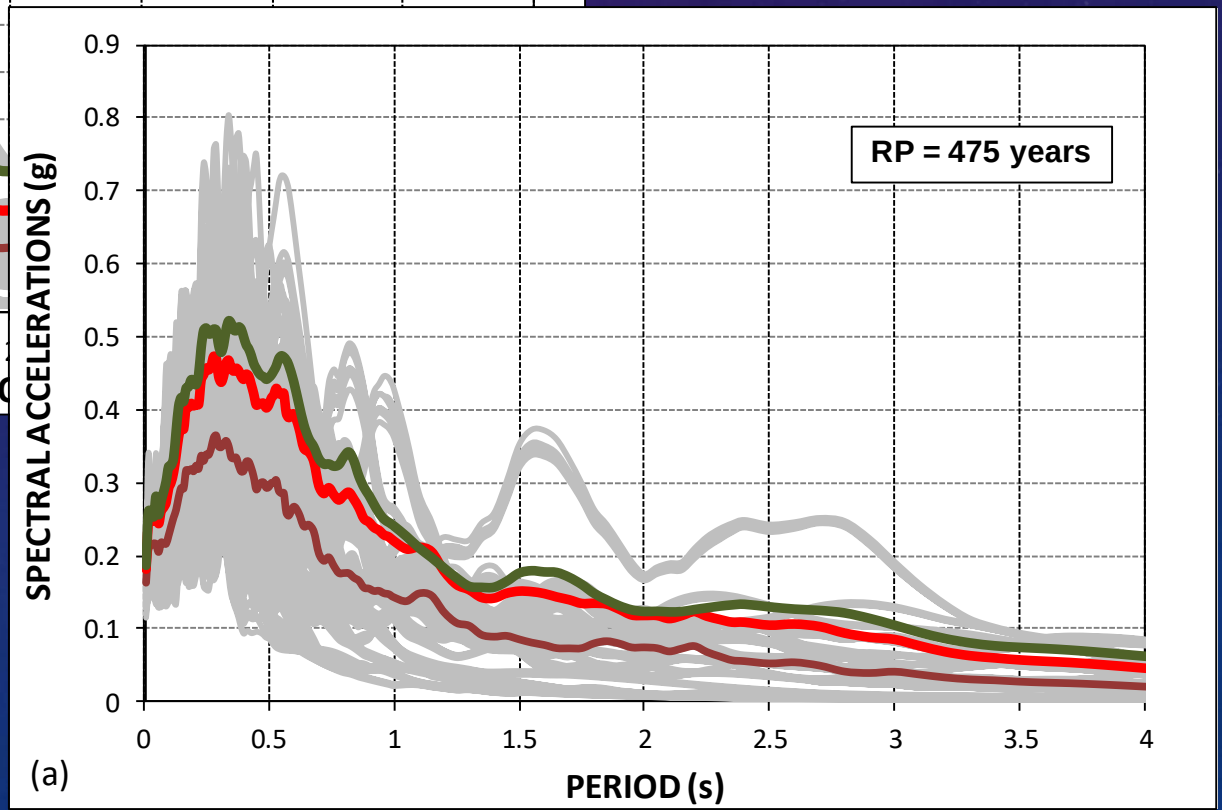
SIMPLIFIED INTERPRETATION CASE 2



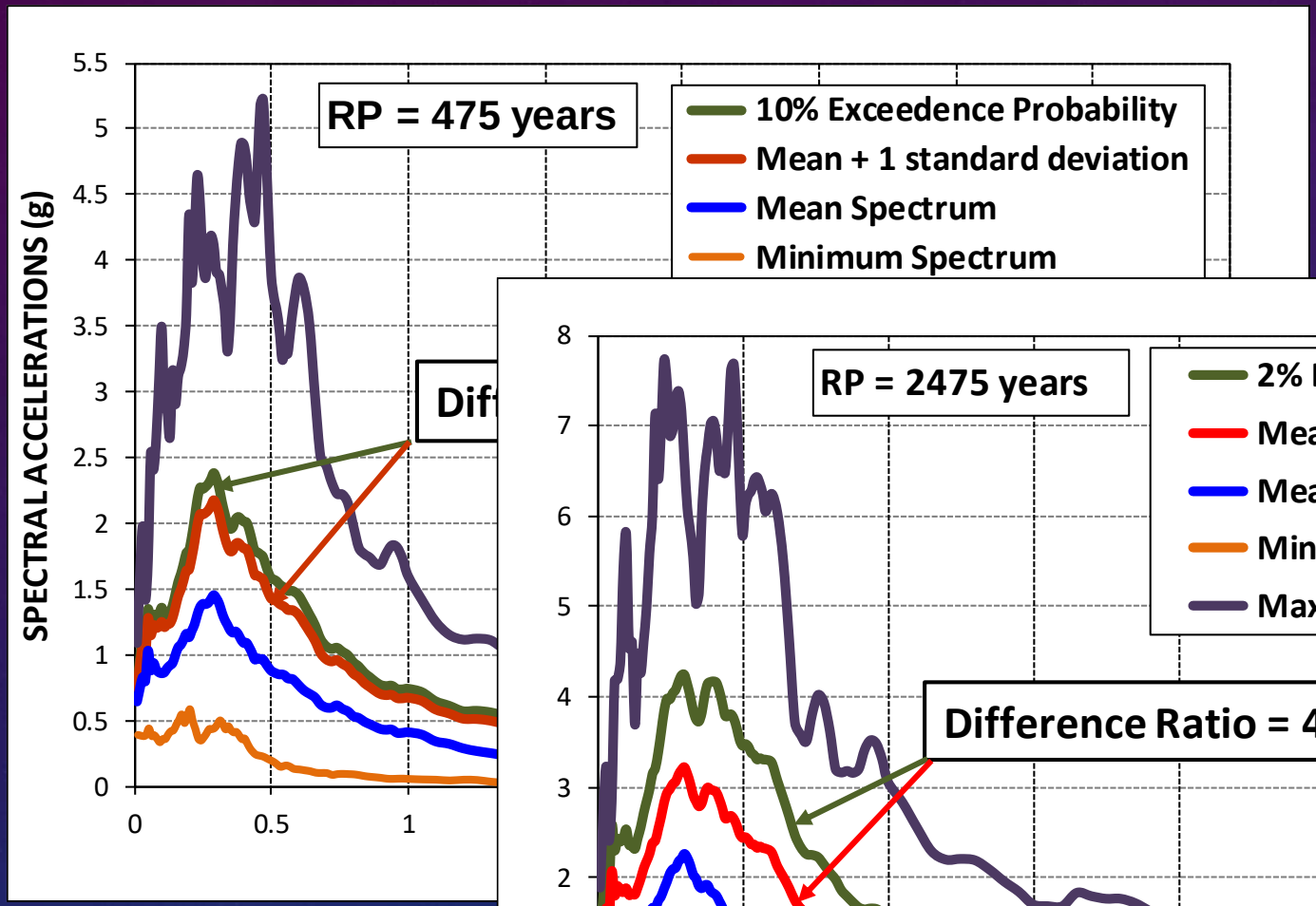


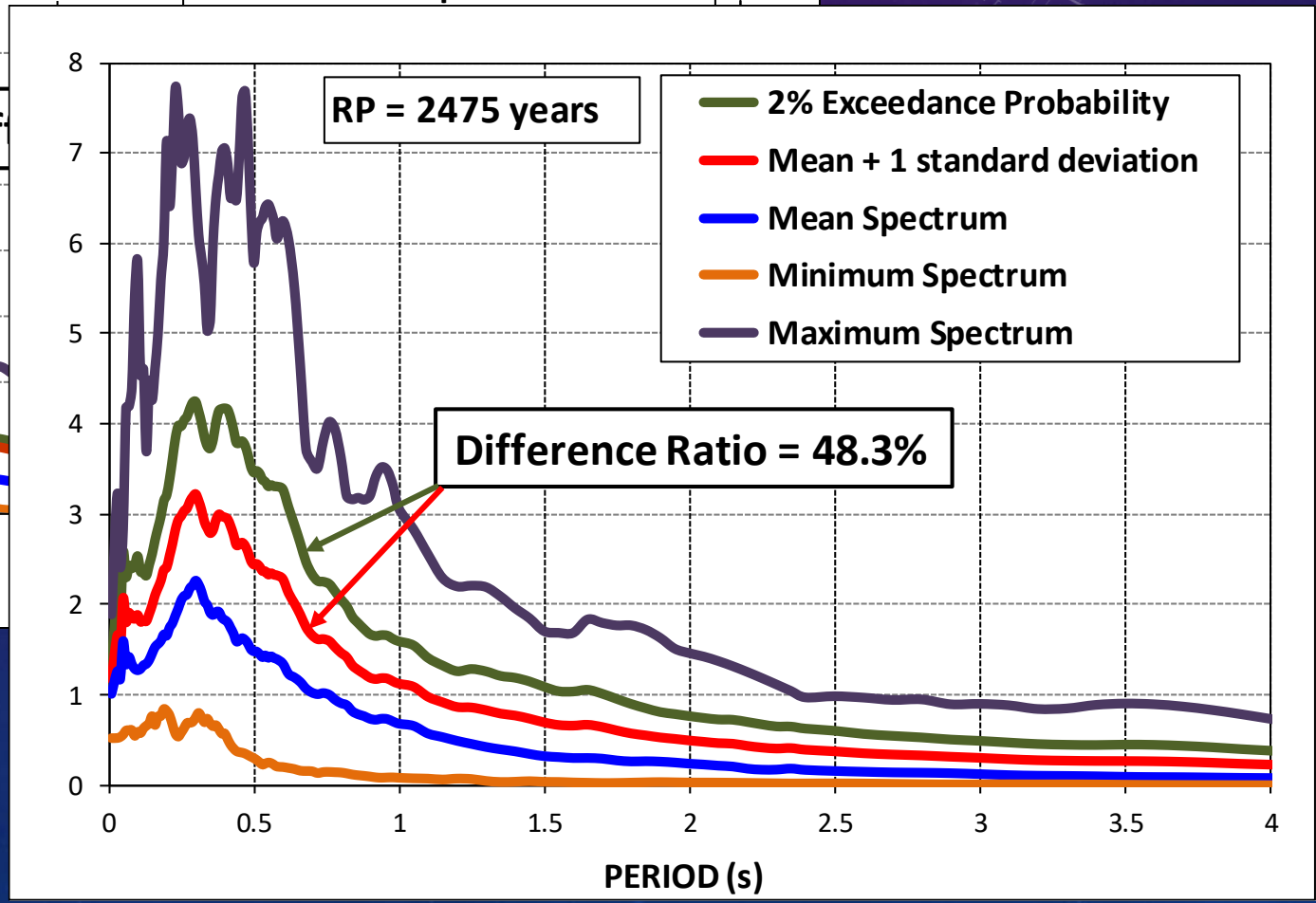
ACCELERATION SPECTRA ON THE GROUND SURFACE



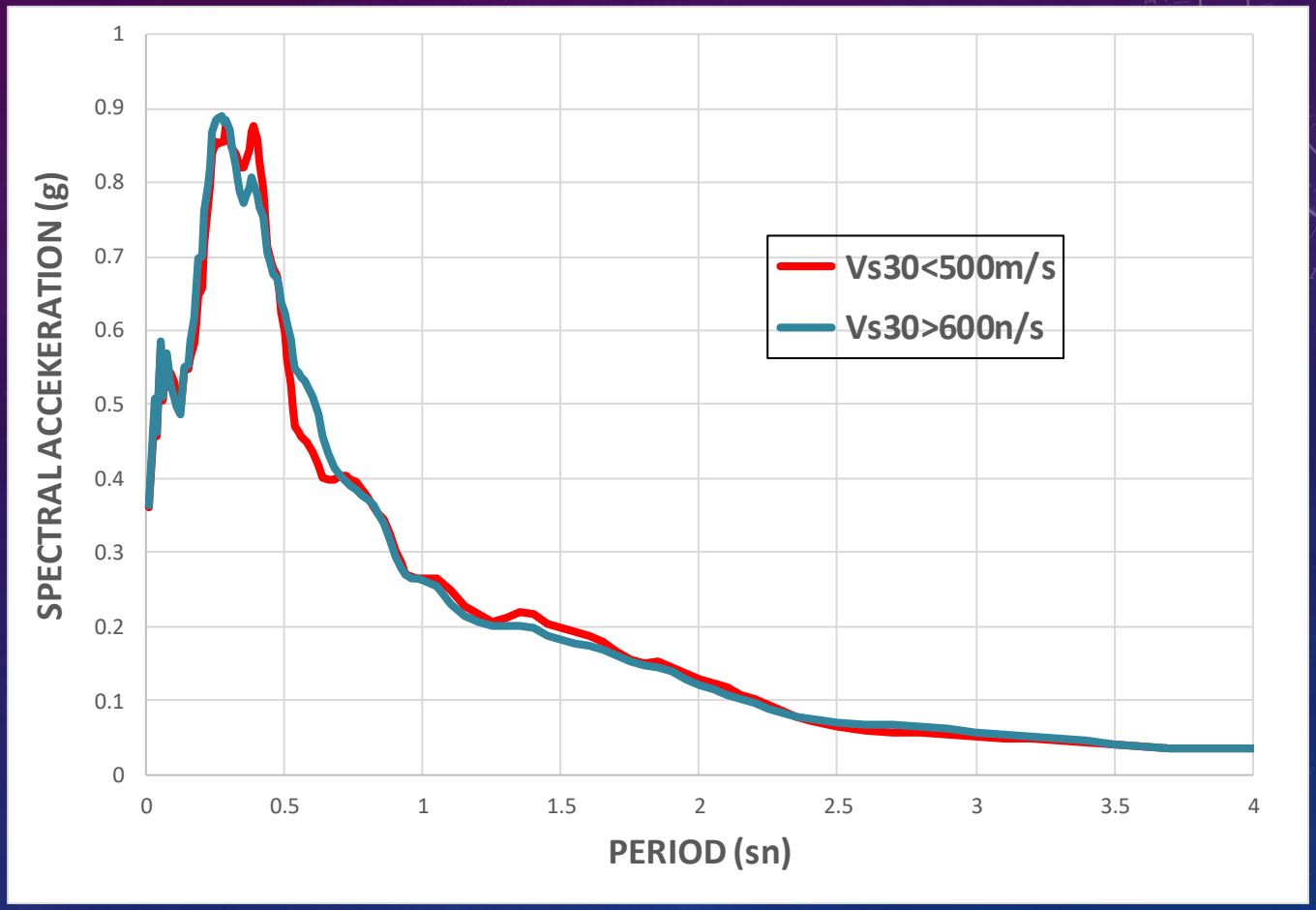


The range of acceleration spectra on the ground surface

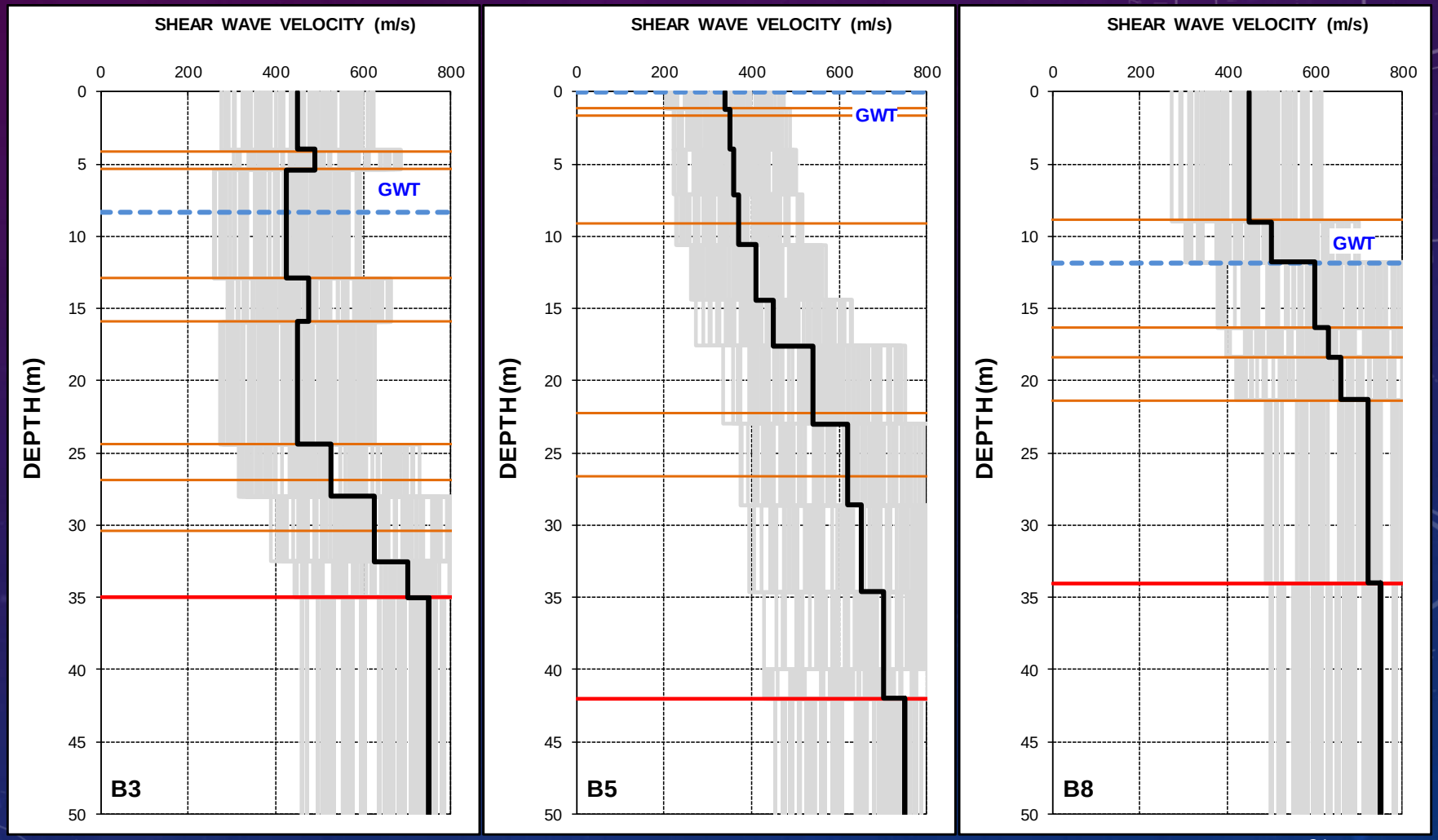




The effect of bedrock definition

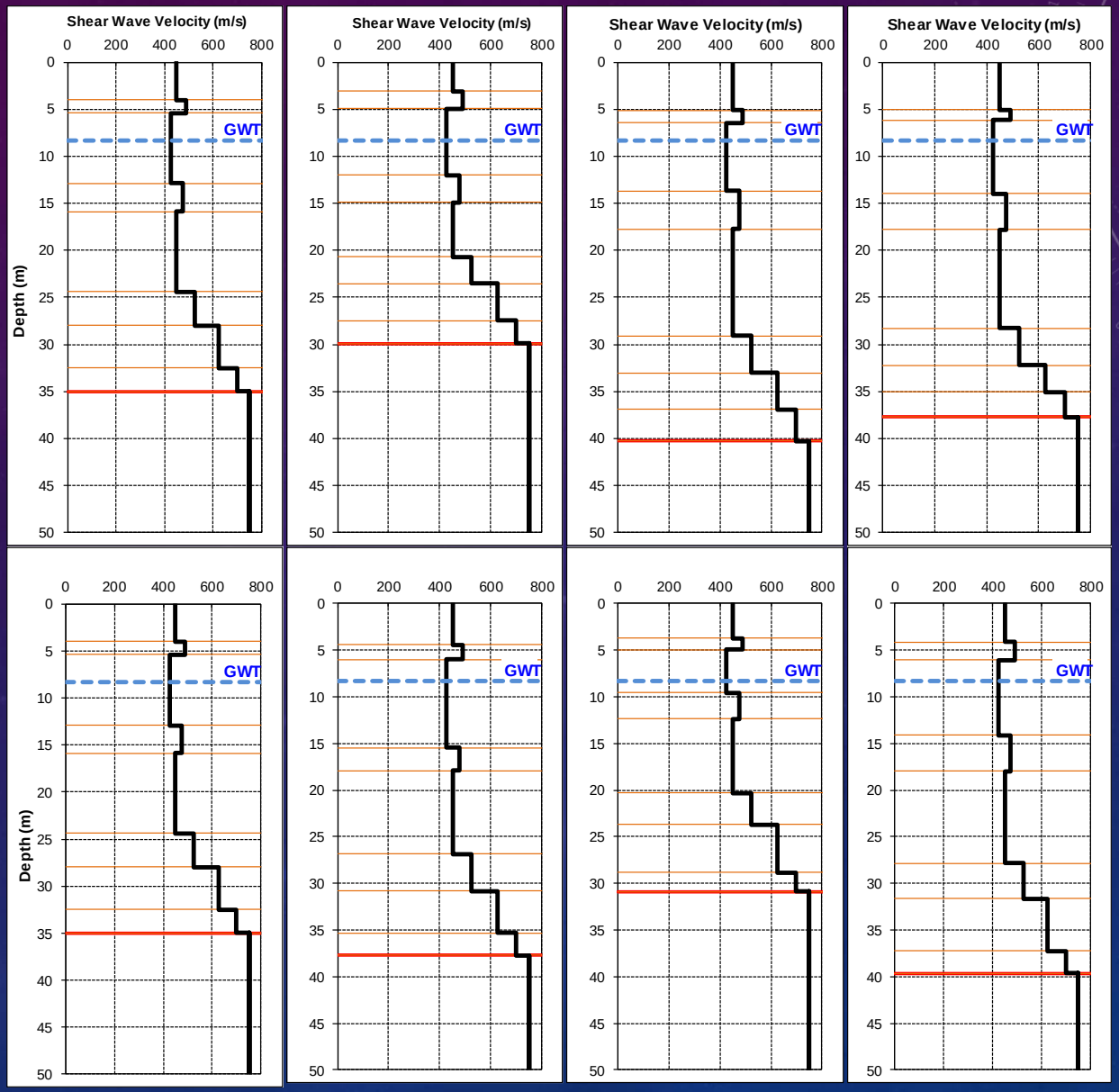


VARIABILITY WRT TO SHEAR WAVE VELOCITIES



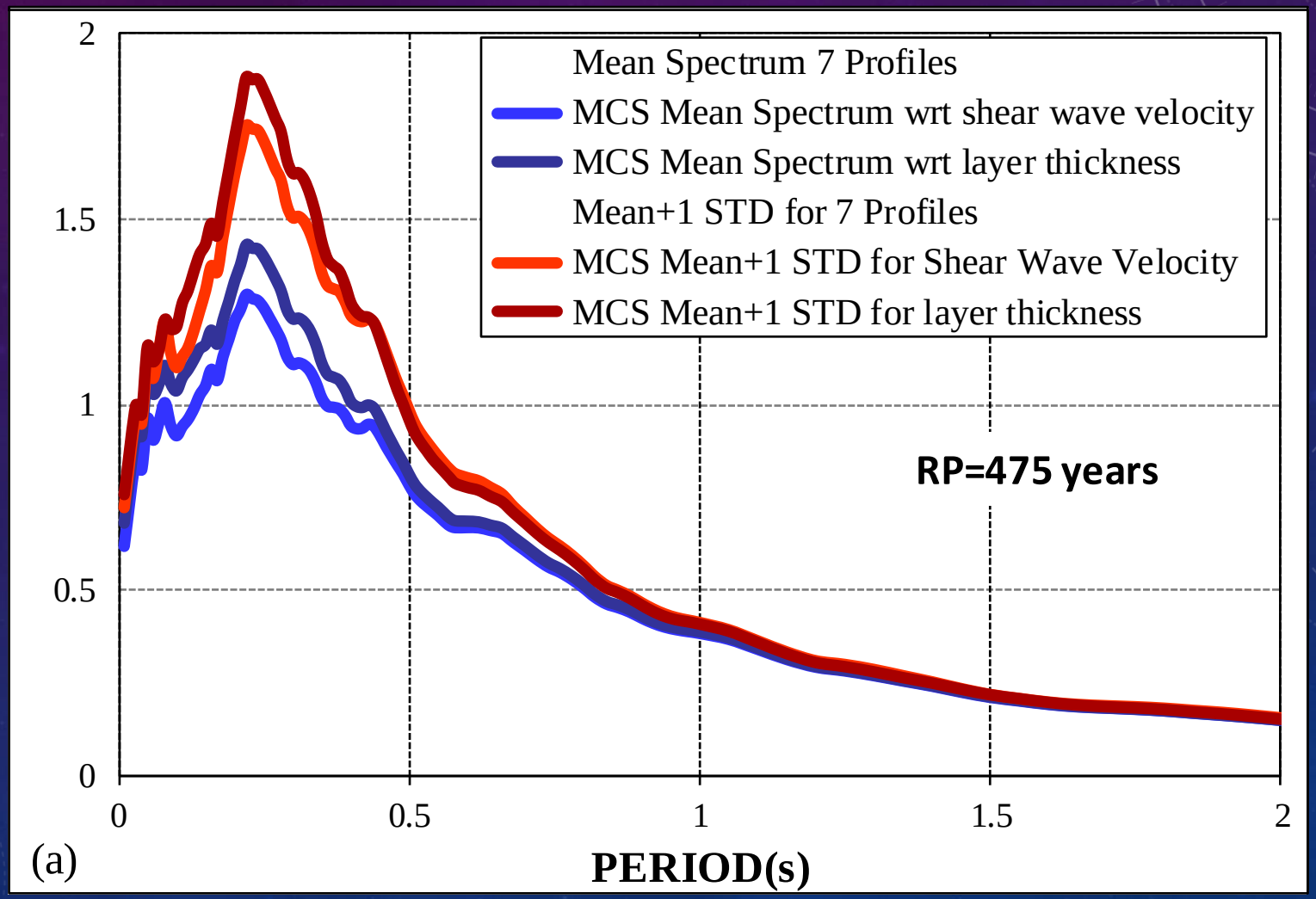
MONTE CARLO SIMULATION WRT TO SHEAR WAVE VELOCITIES

VARIABILITY WRT LAYER THICKNESSES

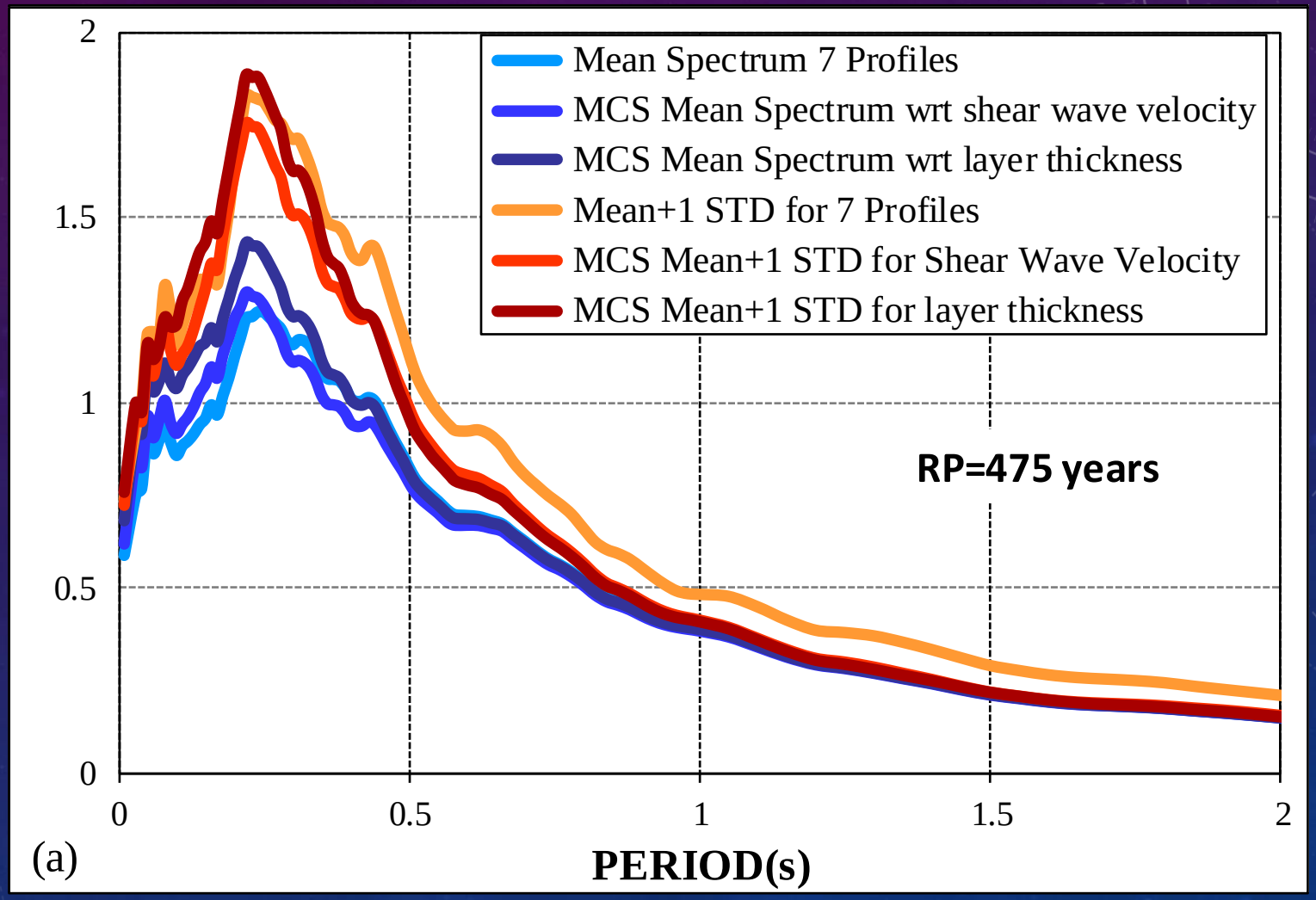


MONTE CARLO SIMULATION WRT TO LAYER THICKNESS

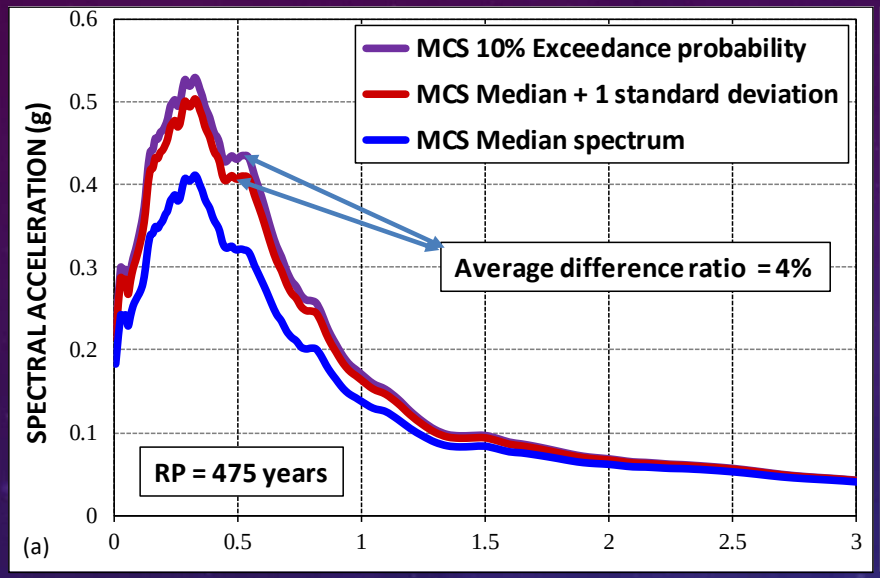
ACCELERATION RESPONSE SPECTRA FOR MCS= 1000 FOR SHEAR WAVE VELOCITY AND LAYER THICKNESS

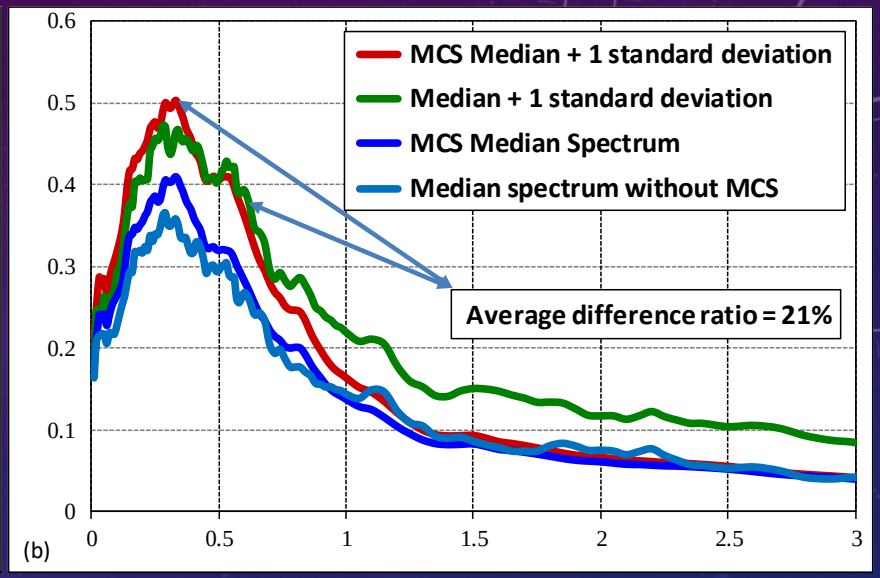


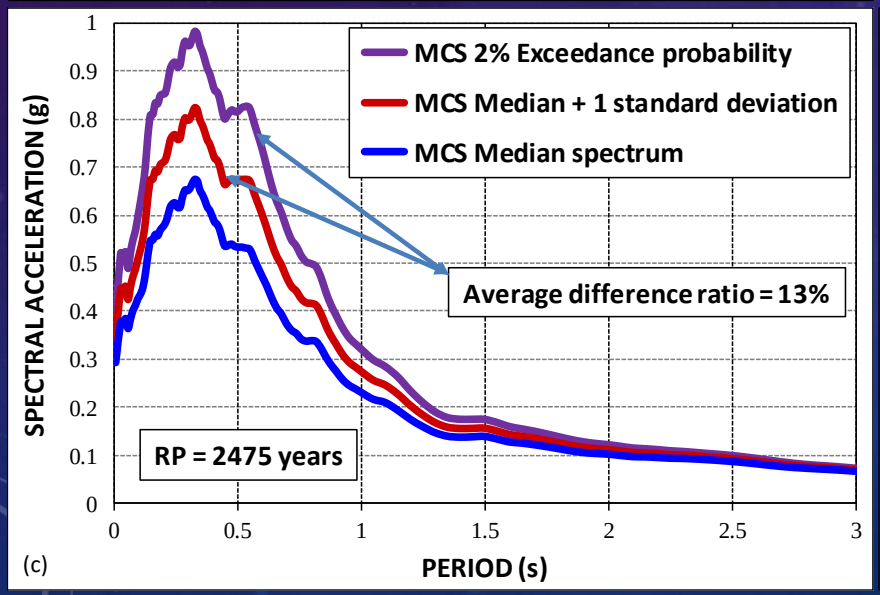
ACCELERATION RESPONSE SPECTRA FOR MCS= 1000 IN COMPARISON TO NO MCS

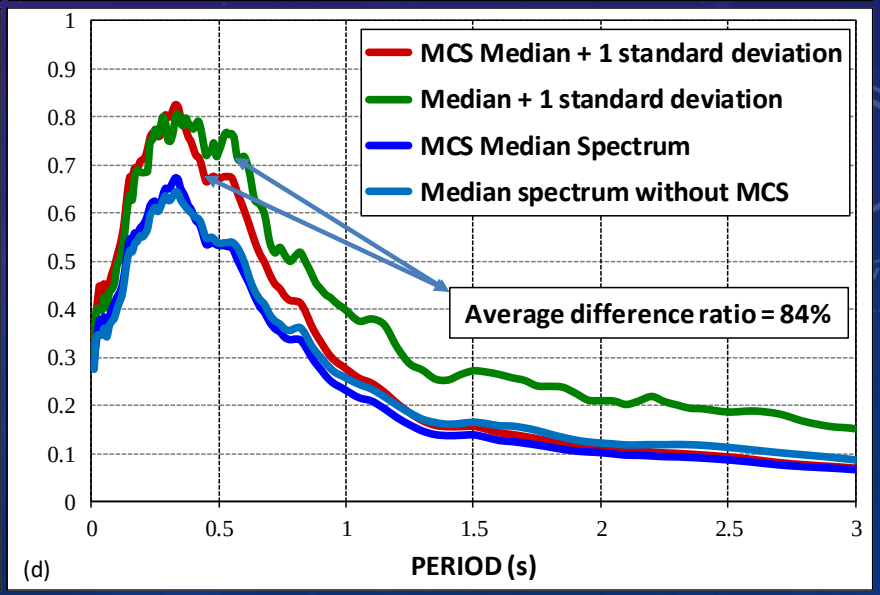


ACCELERATION SPECTRA WITH AND WITHOUT MONTE CARLO SIMULATIONS WRT SHEAR WAVE VELOCITY

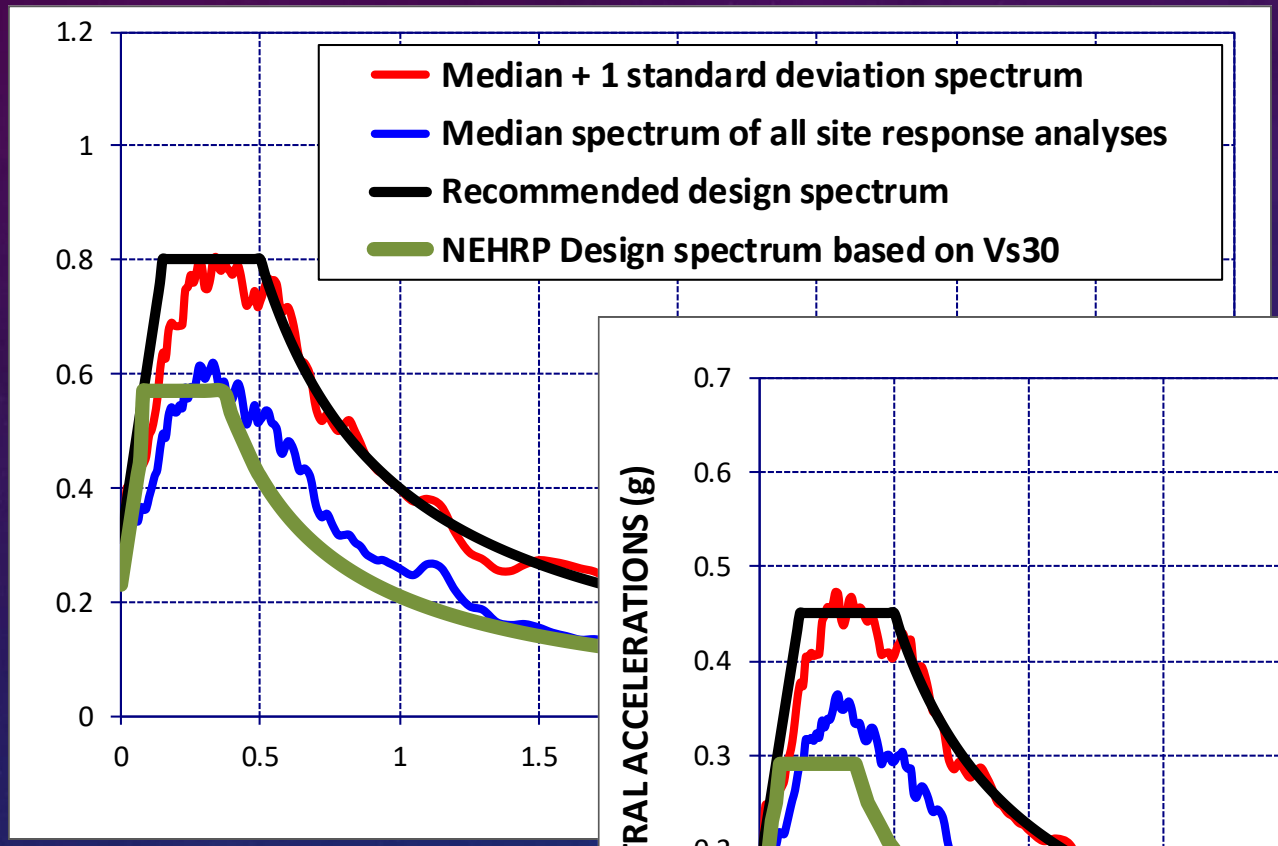


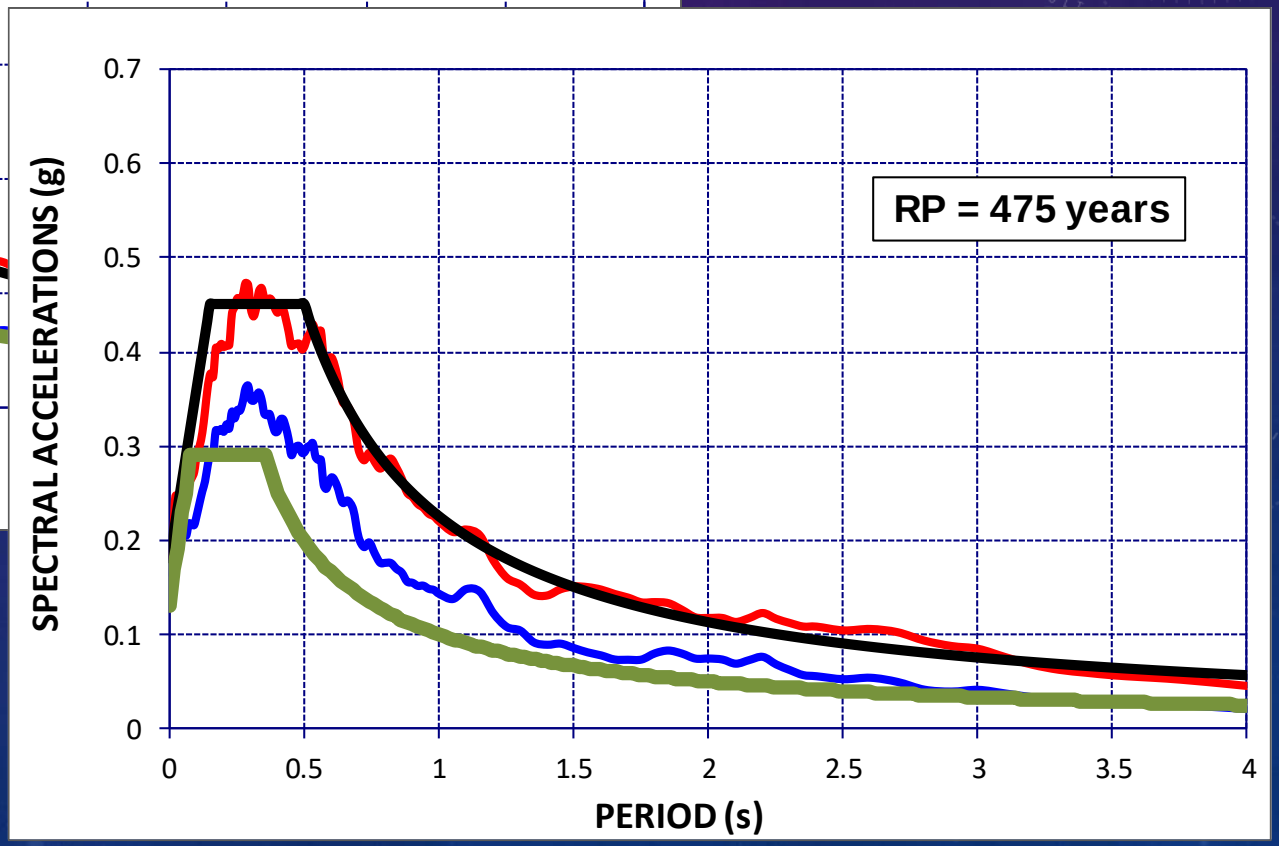




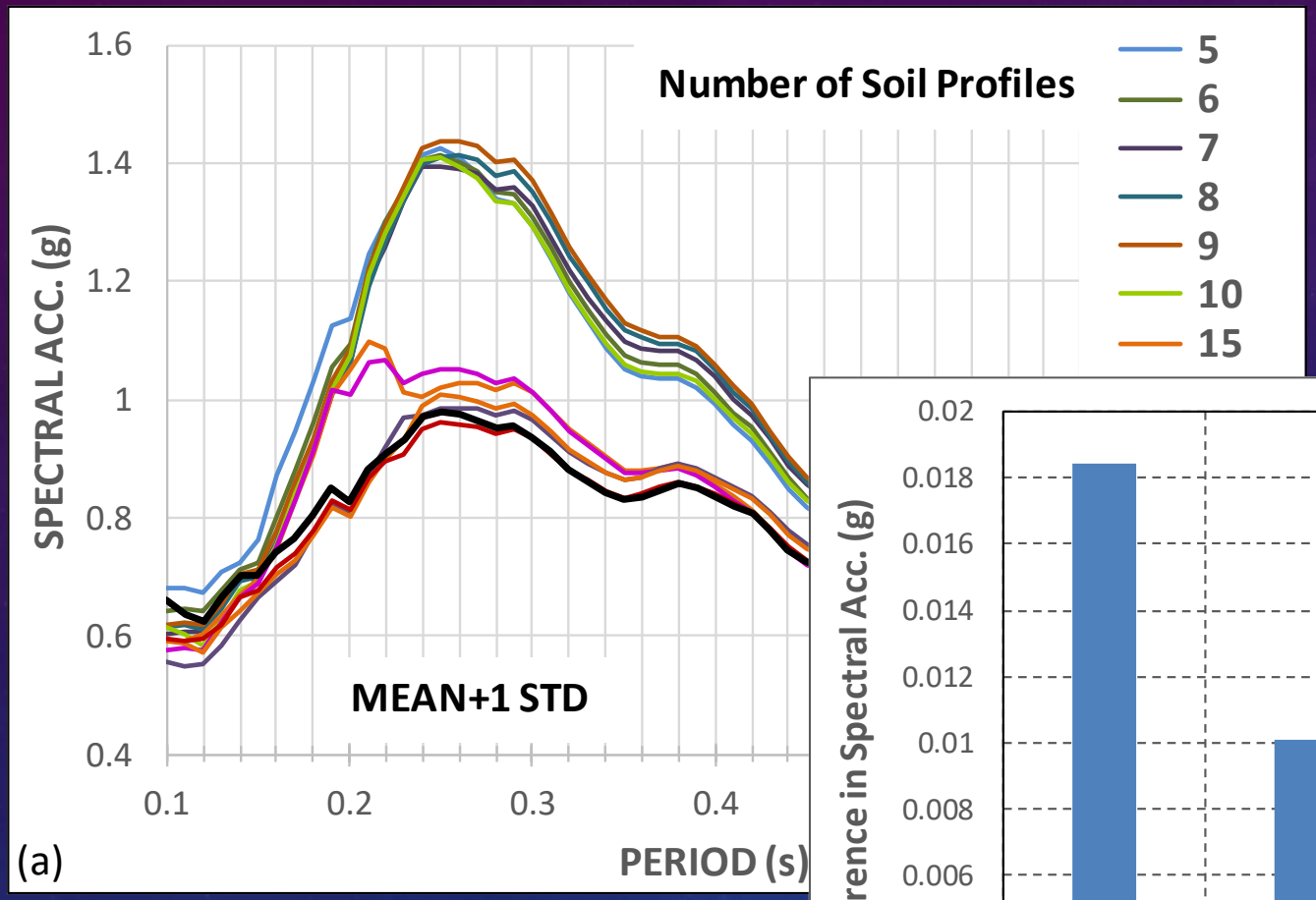


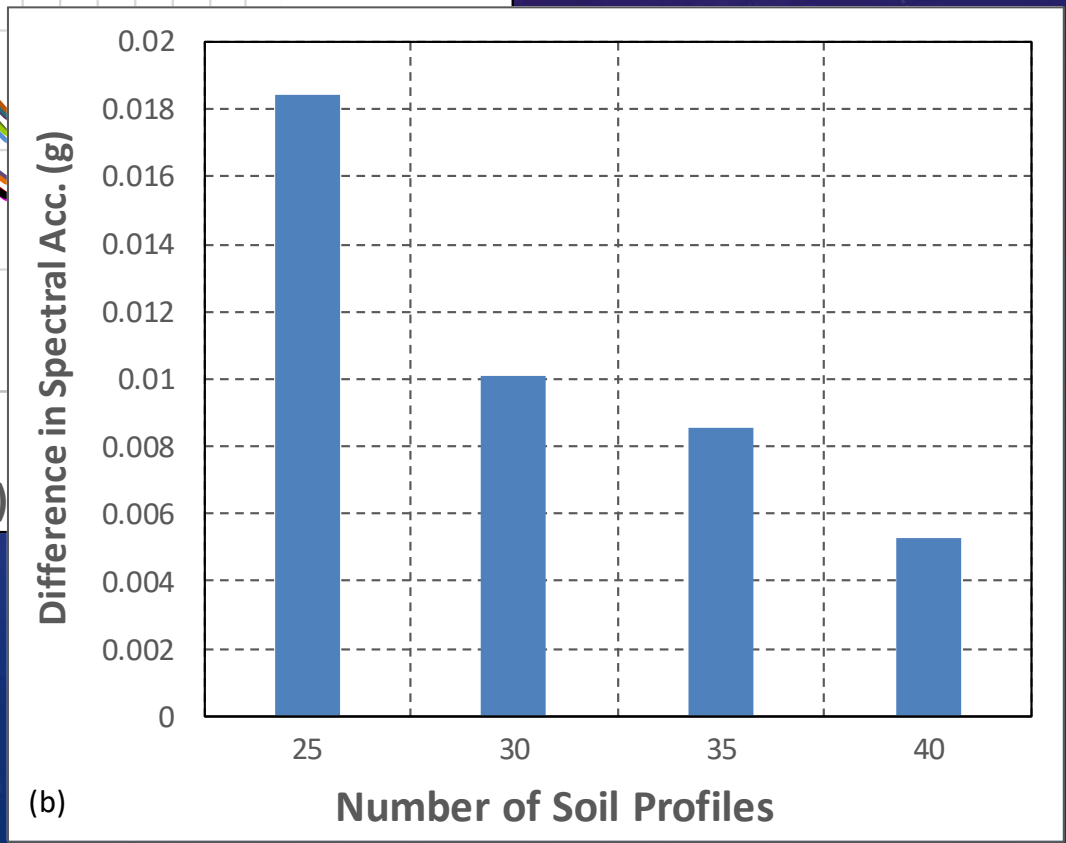
DESIGN ACCELERATION SPECTRA BASED ON SITE RESPONSE ANALYSİS AND NEHRP V_{S30}



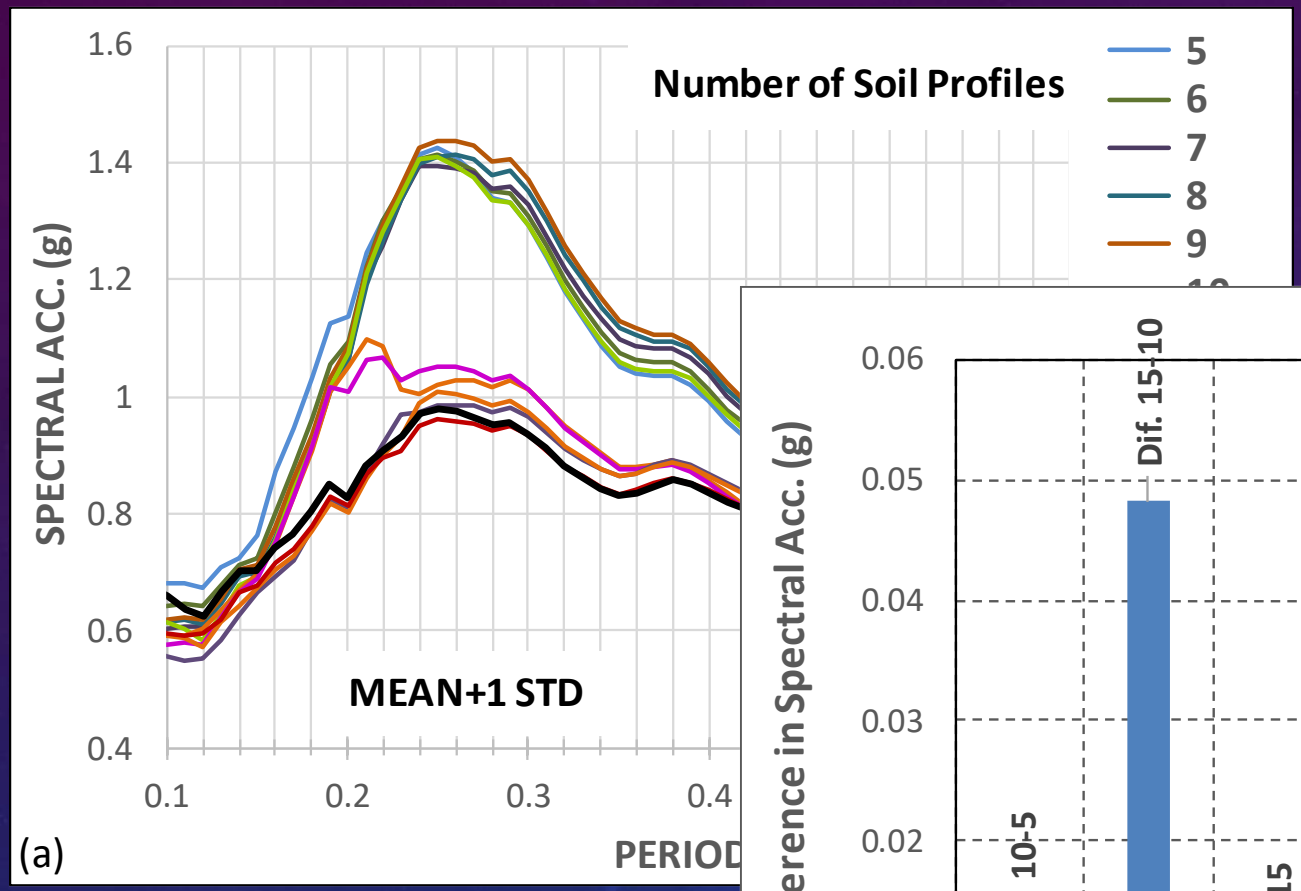


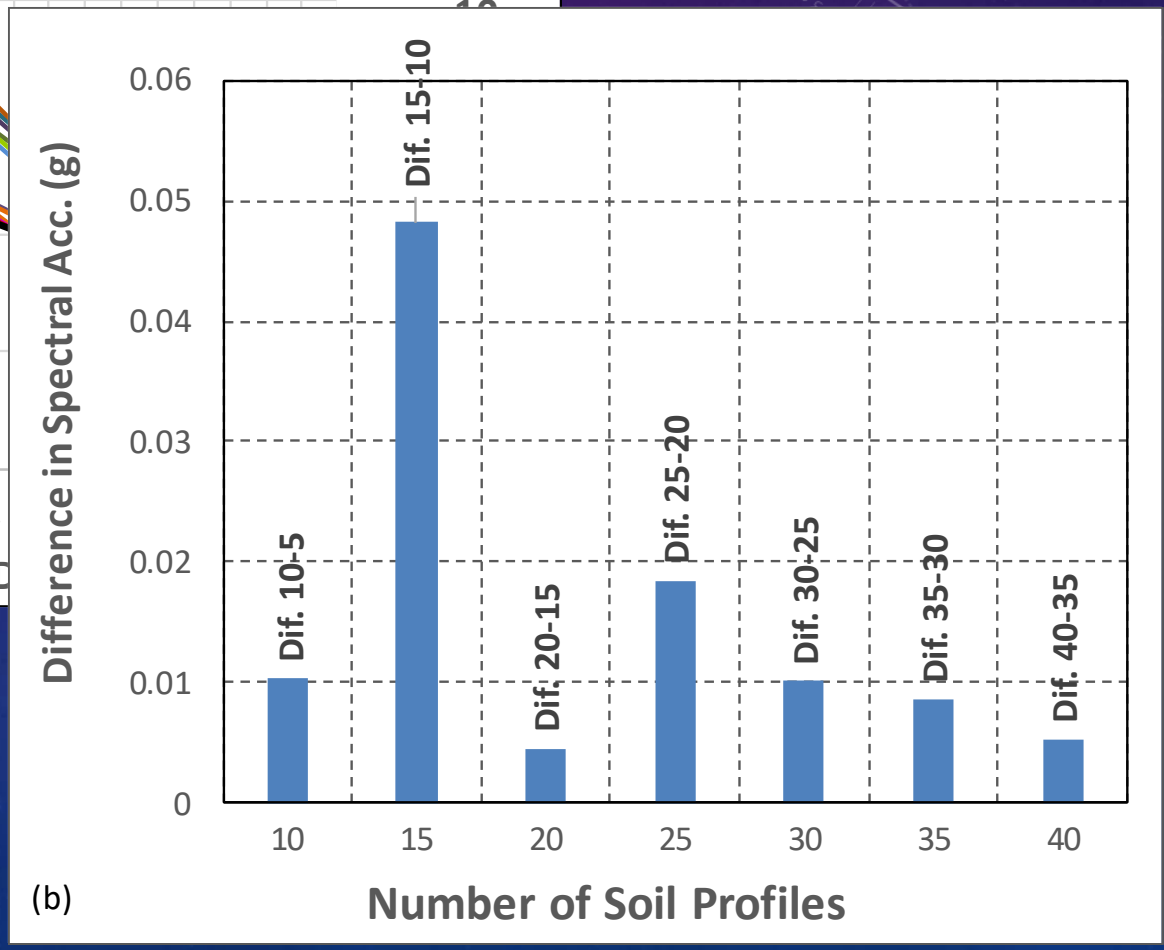
EFFECT OF NUMBER OF SOIL PROFILES



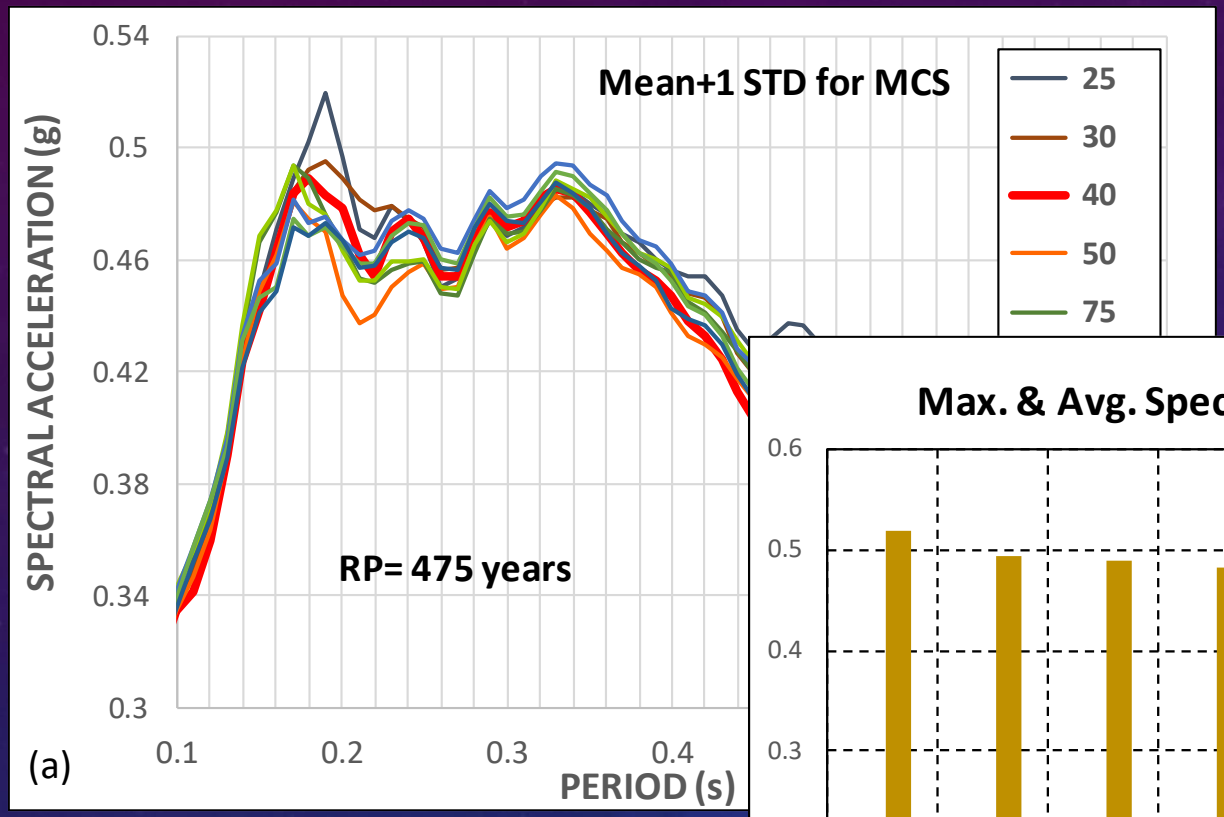


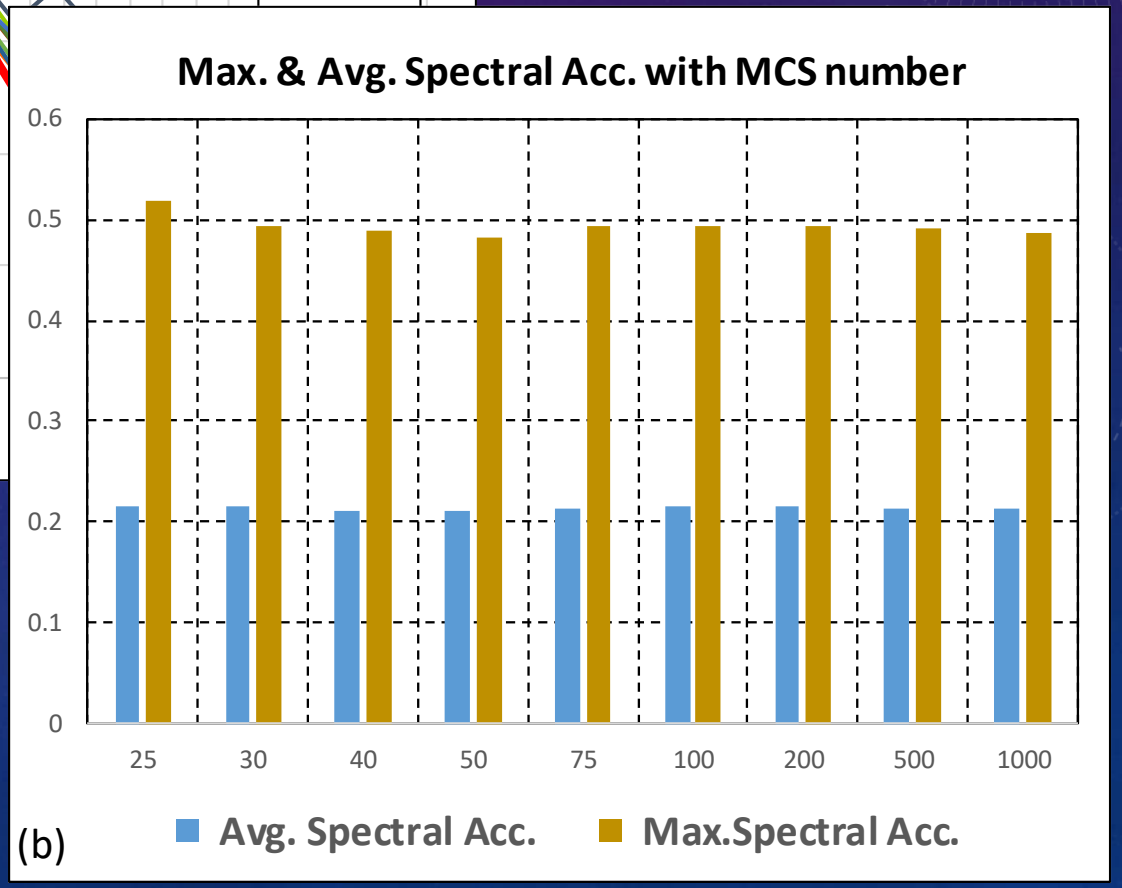
EFFECT OF NUMBER OF SOIL PROFILES



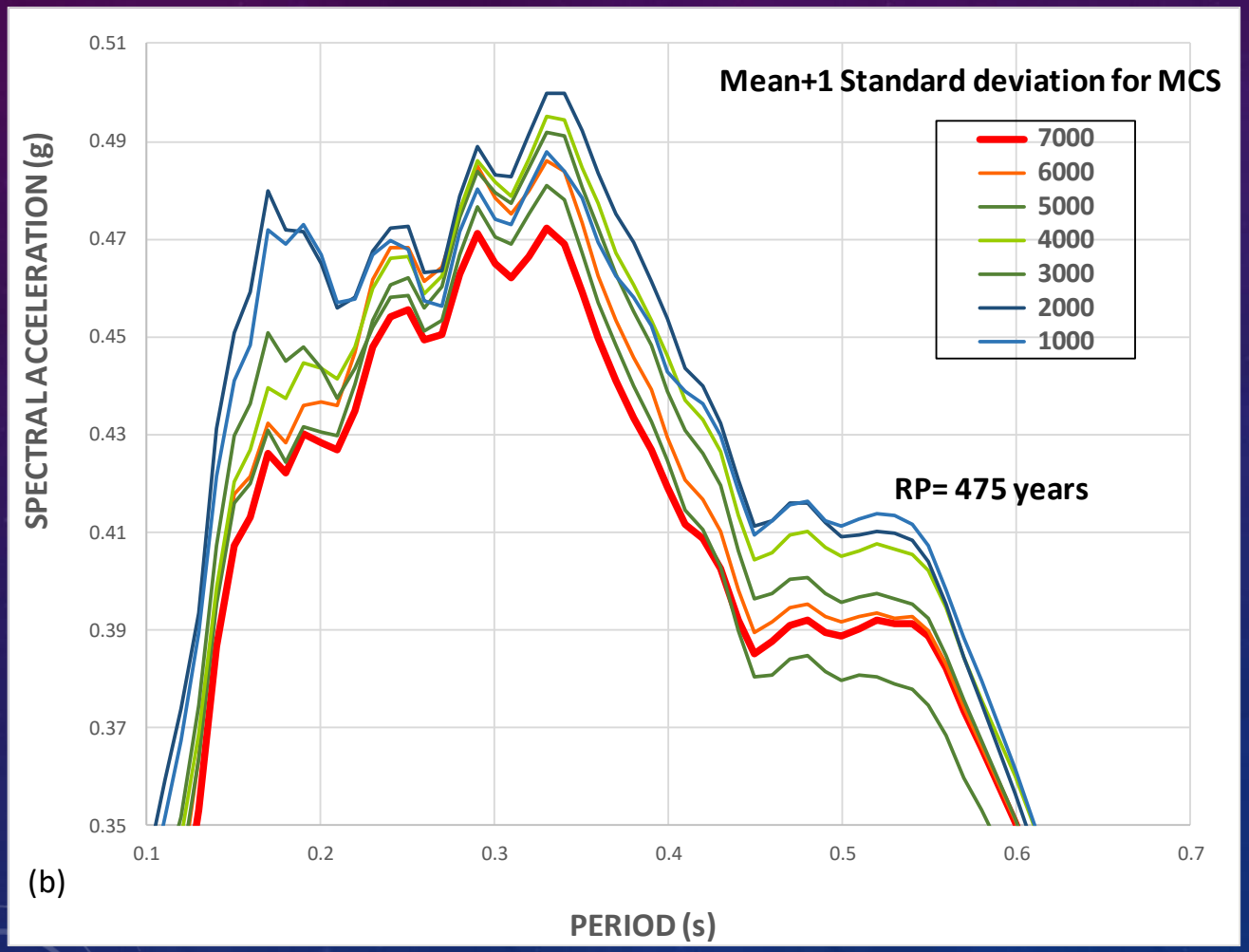


EFFECT OF NUMBER OF SOIL PROFILES

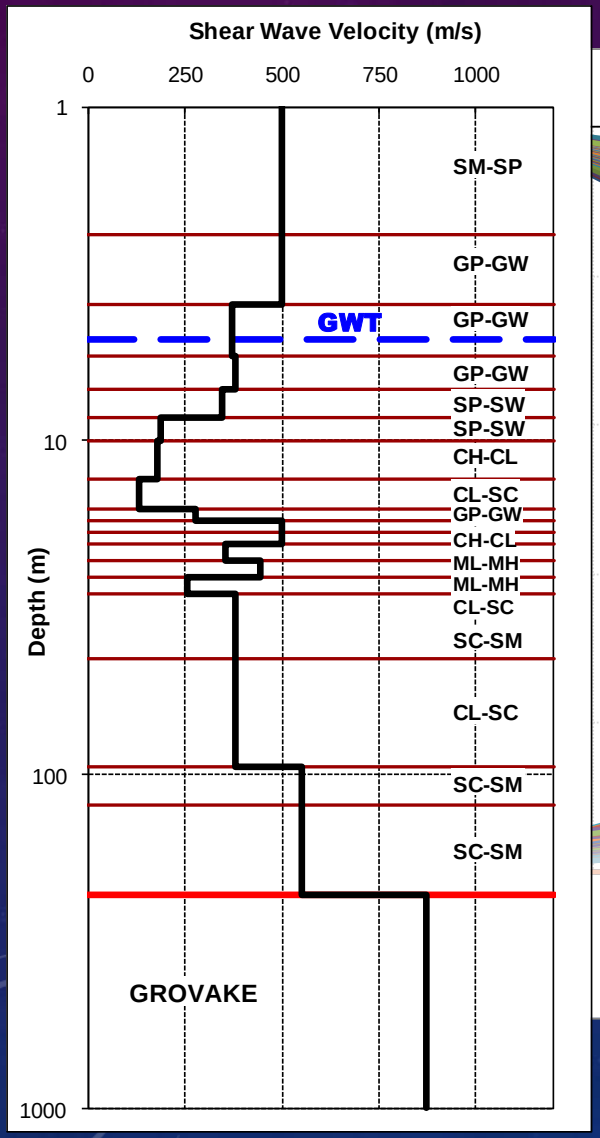


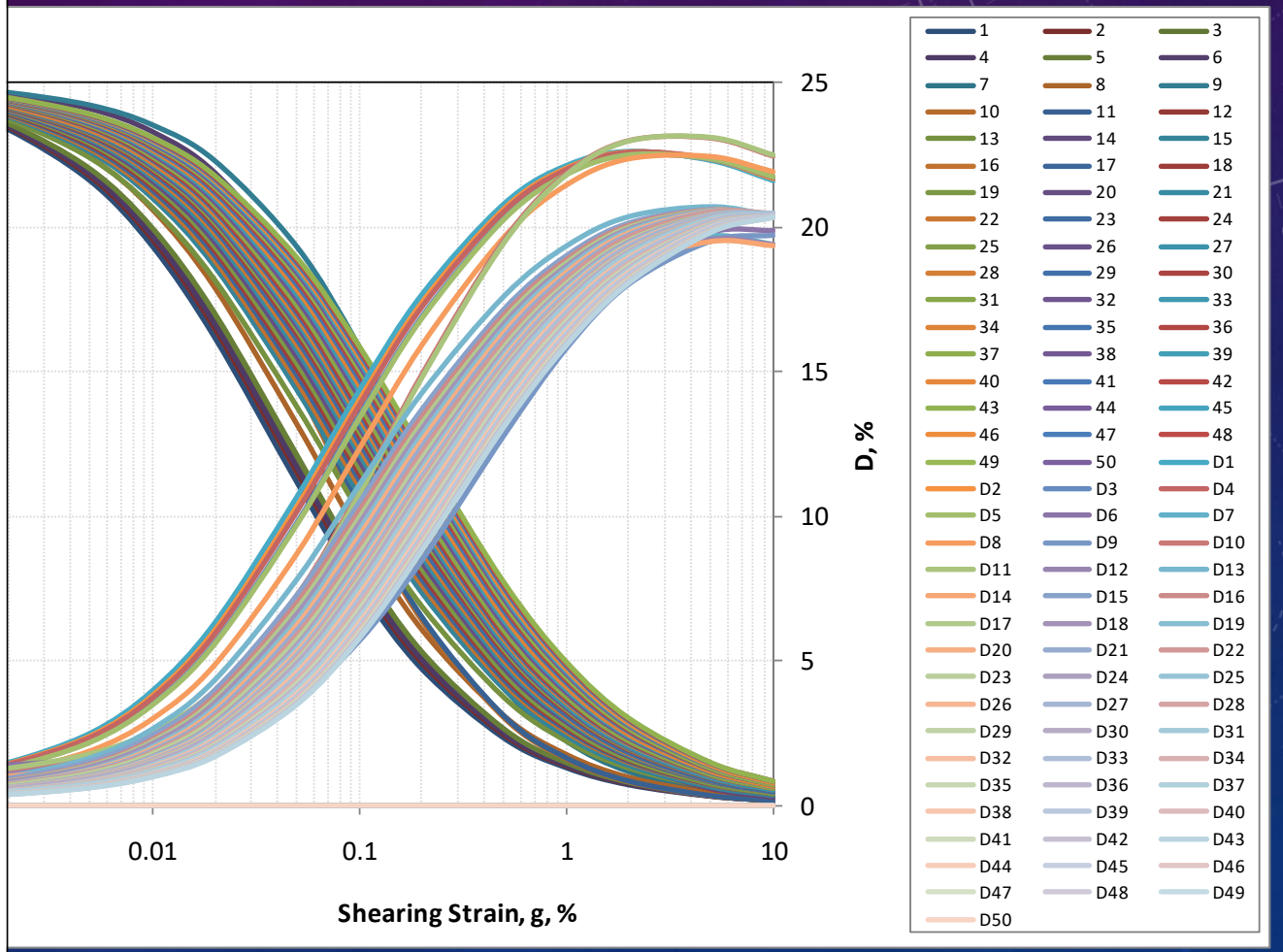


EFFECT OF NUMBER OF SOIL PROFILES

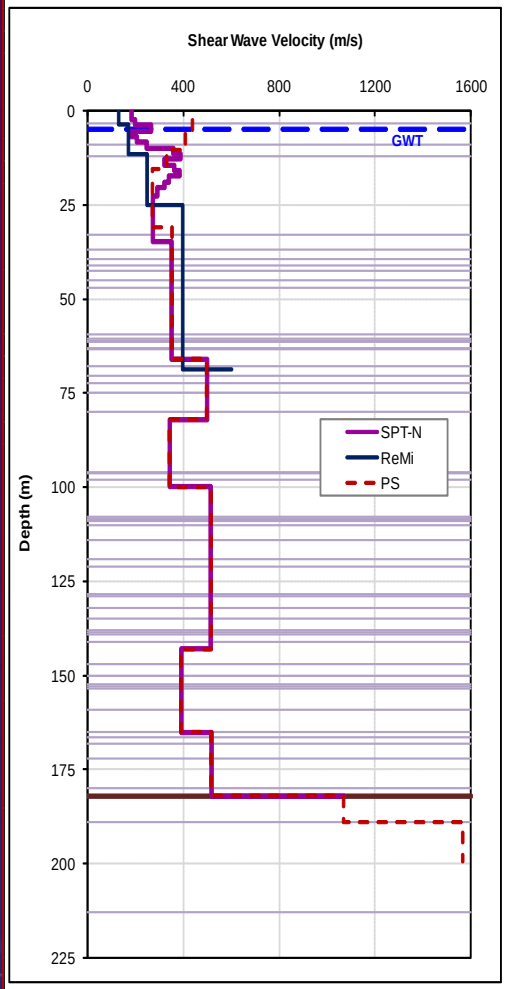


MODULUS REDUCTION AND DAMPING RATIO STRESS DEPENDENCE & FREQUENCY CORRECTION

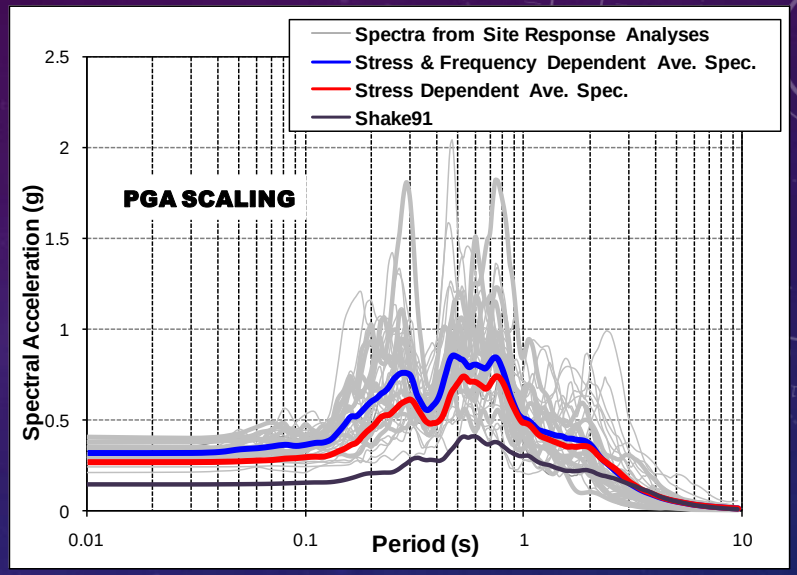


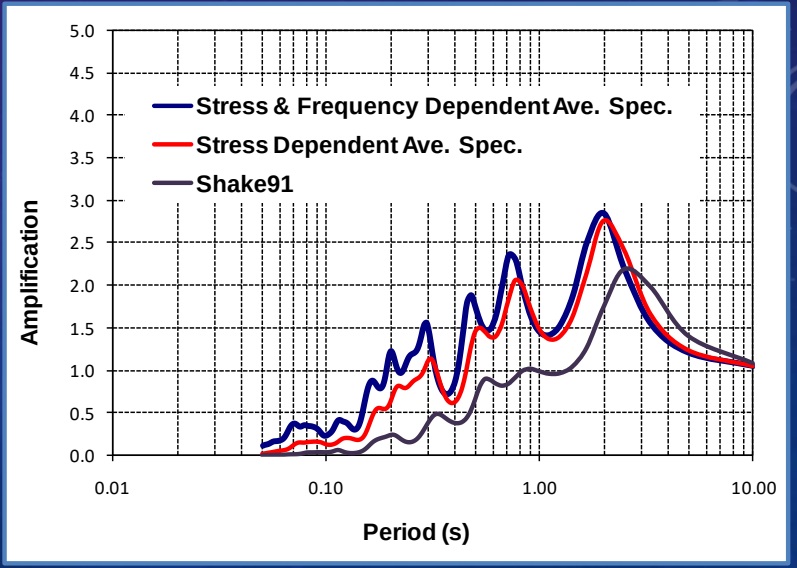


MODIFICATIONS TO SHAKE91 – CASE 1

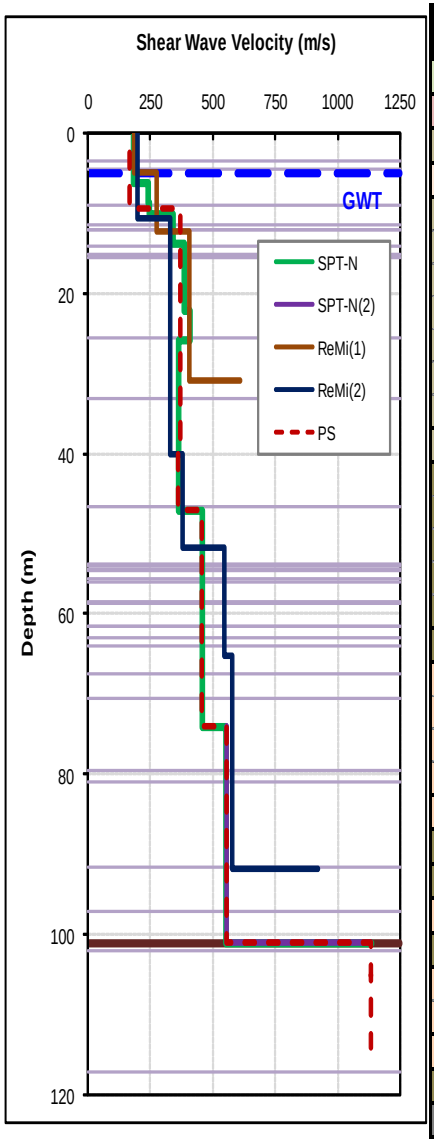


Formation	Top Depth of Layer (m)	Bottom Depth of Layer (m)	Lithology
Fill Material	0	3.5	Fill (GM-GC)
Alluvium	3.5	9	Clay (CH, CL)
Alluvium	9	12	Sand (ML)
Güngören	12	33	Clay (CH, CL)
Gürpınar	33	37	Claystone
Gürpınar	37	39.5	Sandstone
Gürpınar	39.5	41	Clay
Gürpınar	41	42.5	Claystone
Gürpınar	42.5	45	Sand
Gürpınar	45	47	Clay
Gürpınar	47	59.5	Claystone
Gürpınar	59.5	60.5	Sandstone
Gürpınar	60.5	61	Siltstone
Gürpınar	61	61.5	Sandstone
Gürpınar	61.5	63	Sand
Gürpınar	63	63.5	Claystone
Gürpınar	63.5	68	Sand
Gürpınar	68	70.5	Claystone
Gürpınar	70.5	72.5	Sand
Gürpınar	72.5	75	Siltstone
Gürpınar	75	80	Claystone
Gürpınar	80	96	Sand
Gürpınar	96	96.4	Claystone
Gürpınar	96.4	98	Sandstone
Gürpınar	98	108	Claystone
Gürpınar	108	108.5	Sandstone
Gürpınar	108.5	109	Claystone
Gürpınar	109	110	Sandstone
Gürpınar	110	114	Siltstone
Gürpınar	114	119	Sandstone
Gürpınar	119	121	Claystone
Gürpınar	121	128.5	Sand
Gürpınar	128.5	129	Claystone
Gürpınar	129	132	Sand
Gürpınar	132	135	Claystone
Gürpınar	135	138	Sandstone
Gürpınar	138	138.5	Siltstone
Gürpınar	138.5	139	Claystone
Gürpınar	139	141	Sandstone
Gürpınar	141	147	Sand
Gürpınar	147	150	Gravel
Gürpınar	150	152.5	Sand
Gürpınar	152.5	153	Siltstone
Gürpınar	153	153.5	Gravel
Gürpınar	153.5	159	Siltstone
Gürpınar	159	165	Sand
Gürpınar	165	166.5	Gravel
Gürpınar	166.5	168	Sandstone
Gürpınar	168	172	Sand
Gürpınar	172	180	Sand
Gürpınar	180	189	Sandstone
Trakya	189	213	Graywacke

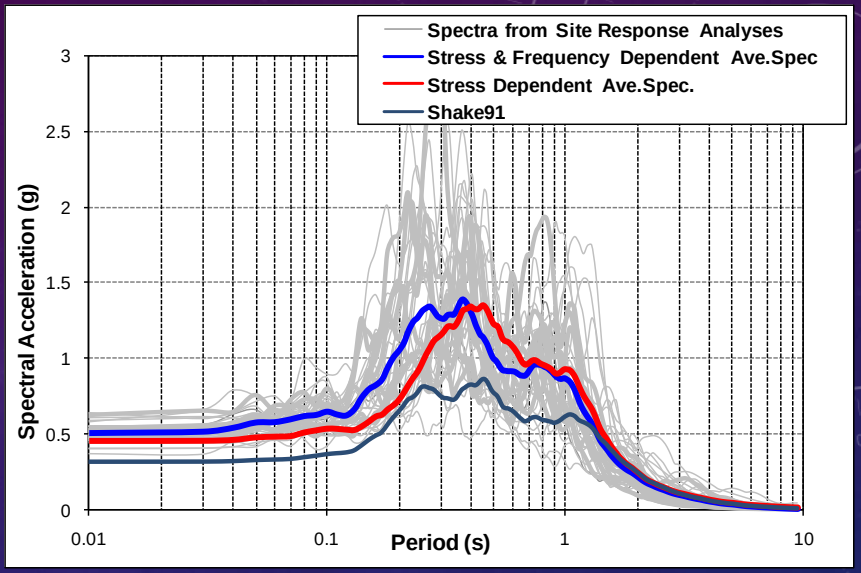


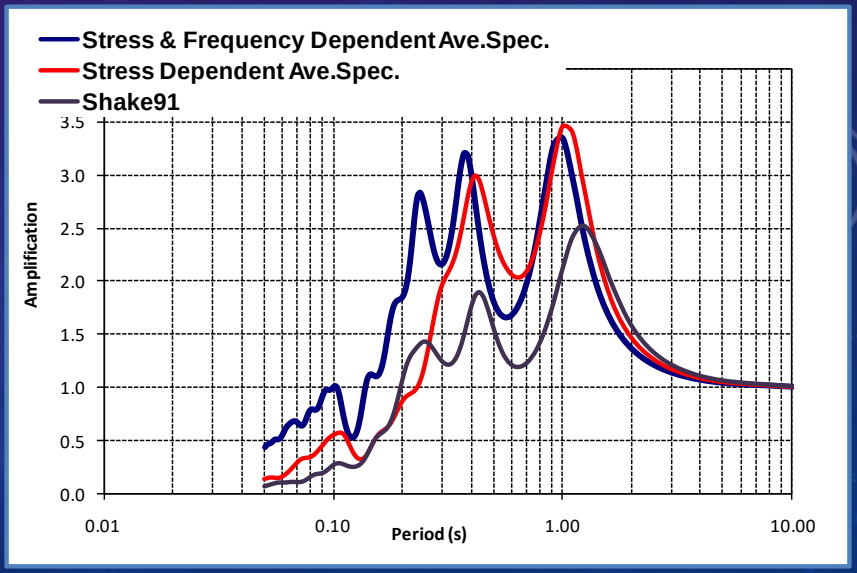


MODIFICATIONS TO SHAKE91 – CASE 2



Formation	Top Depth of Layer (m)	Bottom Depth of Layer (m)	Lithology
Fill Material	0	3.5	Fill
Bakırköy	3.5	4.5	Clay (ML)
Güngören	4.5	9	Clay (CL-CH)
Güngören	9	11.5	Sand (CH)
Güngören	11.5	12	Clay
Güngören	12	12.1	Marn
Güngören	12.1	14	Clay
Güngören	14	15	Clay
Güngören	15	15.5	Sand
Güngören	15.5	25.5	Clay (CL, CL-CH, SM-SC)
Güngören	25.5	33	Clay (CL-CH)
Güngören	33	46.5	Clay
Gürpınar	46.5	53.8	Claystone
Gürpınar	53.8	54	Marn
Gürpınar	54	54.3	Claystone
Gürpınar	54.3	54.5	Marn
Gürpınar	54.5	55.5	Claystone
Gürpınar	55.5	56	Clay
Gürpınar	56	58.5	Sand
Gürpınar	58.5	58.7	Siltstone
Gürpınar	58.7	61.4	Sand
Gürpınar	61.4	61.5	Marn
Gürpınar	61.5	63	Sand
Gürpınar	63	64	Claystone
Gürpınar	64	67.5	Clay
Gürpınar	67.5	70.5	Sand
Gürpınar	70.5	79.5	Claystone
Gürpınar	79.5	81	Sand
Gürpınar	81	91.5	Sand
Gürpınar	91.5	97	Sand
Gürpınar	97	102	Clay
Trakya	102	117	Graywacke





CONCLUSIONS

1. It is possible to develop a simplified procedure to determine acceleration design response spectrum on the ground surface.
2. The approach is based on the determination of amplification function based on major factors affecting site response analysis.
3. Based on performing multiple number of site response analysis using hazard compatible acceleration records, it was observed that reliable results would be calculated on the ground surface if the number of input acceleration records are in the order of 22-23.
4. Similarly, to account for site variability, the number soil profiles are estimated based on a case study to be in the order of 30 soil profiles.
5. It is possible to define the design uniform hazard acceleration response spectrum based on sufficient number of soil profiles using sufficient number of hazard compatible acceleration time histories adopting a distribution function to evaluate the statistical variation and to calculate the exceedance levels as foreseen in the regional hazard study.

SOURCES OF SCATTER IN SITE RESPONSE ANALYSIS

- Number of acceleration records
- Properties of acceleration records
- Scaling of the acceleration records
- Differences in soil profiles

THE END