A Geotechnical Engineer's Transition from the UBC to the IBC

David A. Baska
Ph.D., P.E., C.E.G.

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Consulting Engineers & Scientists

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UBC End Result

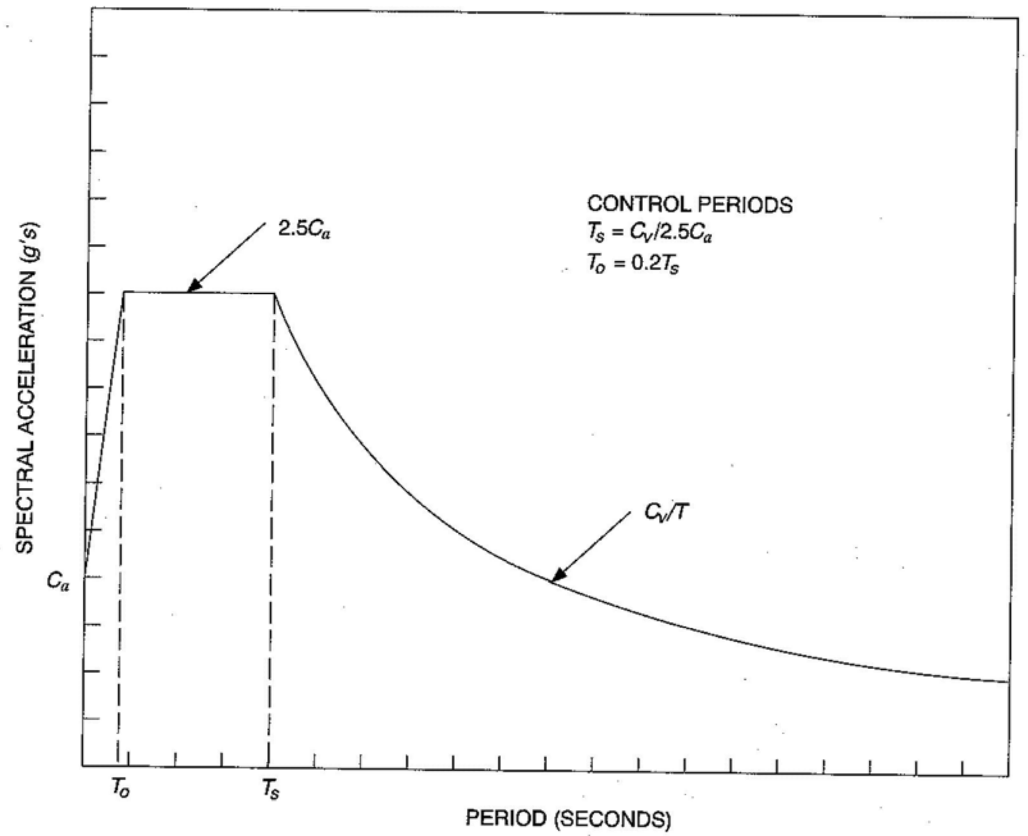


FIGURE 16-3—DESIGN RESPONSE SPECTRA

IBC End Result

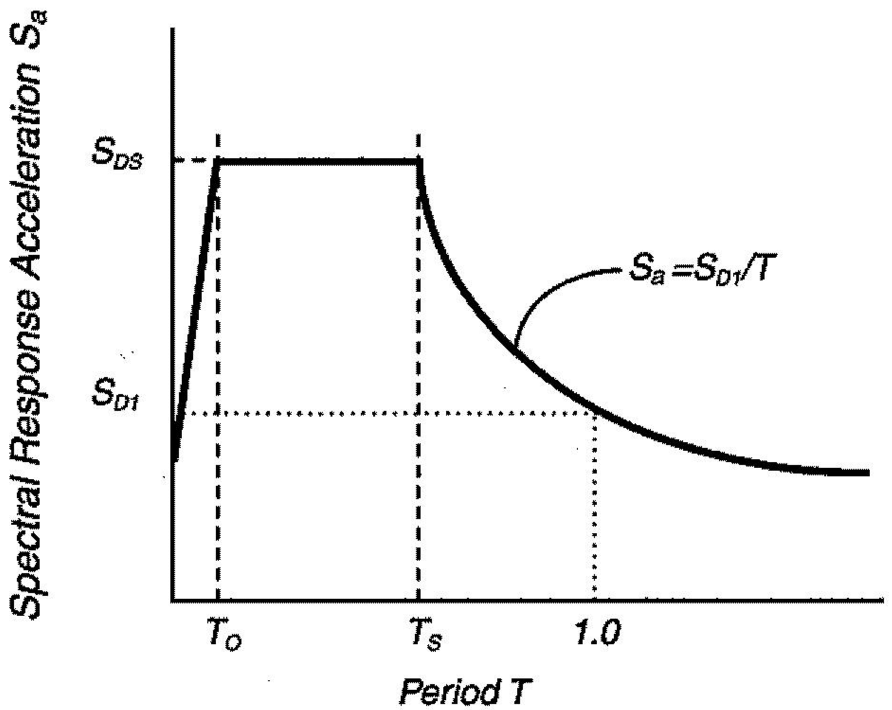


FIGURE 1615.1.4
DESIGN RESPONSE SPECTRUM

Seismic Zone Map

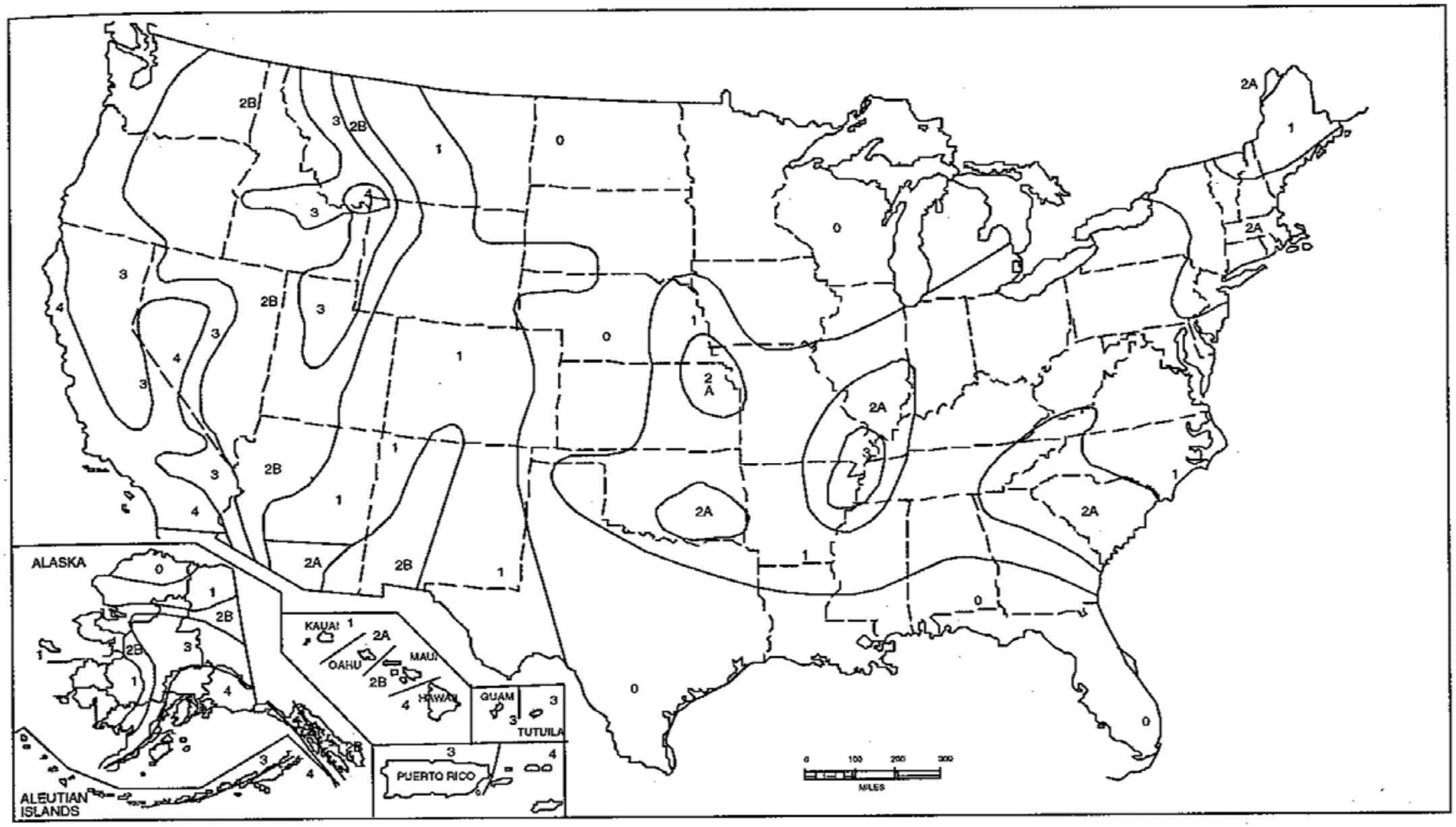
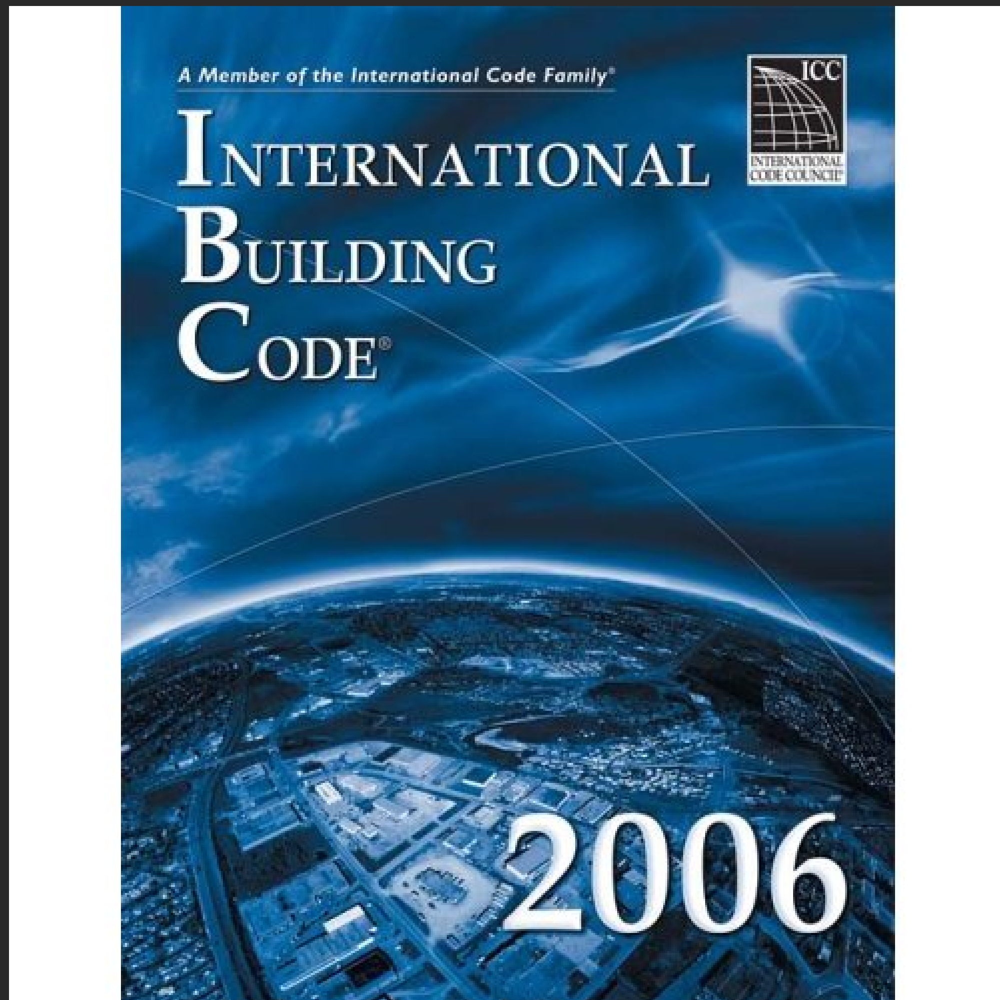


FIGURE 16-2—SEISMIC ZONE MAP OF THE UNITED STATES
For areas outside of the United States, see Appendix Chapter 16.

Seismic Zone Map

FIGURE 16-2—SEISMIC ZONE MAP OF THE UNITED STATES
For areas outside of the United States, see Appendix Chapter 16.

- Seismic zones
- Seismic zone factors
- Zone 4 near-source factors
- Seismic source type


A Member of the International Code Family®
INTERNATIONAL
BUILDING
CODE®
ICC
INTERNATIONAL CODE COUNCIL®
2006

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Minimum Design
Loads for Buildings
and Other Structures
ASCE


A Member of the International Code Family®
ICC
INTERNATIONAL CODE COUNCIL®
INTERNATIONAL BUILDING CODE®
2006
Minimum Design Loads for Buildings and Other Structures

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MCE

(Maximum Considered Earthquake)

Maximum Considered Earthquake (MCE)

2% probability of exceedance in 50 years
(2,500 year return period)

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Maximum Considered Earthquake (MCE)

2% probability of exceedance in 50 years
(2,500 year return period)

Design ground motions set at 2/3 of MCE

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Maximum Considered Earthquake (MCE)

2% probability of exceedance in 50 years
(2,500 year return period)

Design ground motions set at 2/3 of MCE

Design ground motions were set at 2/3 of the MCE ground motion level, with the reasoning that any structure designed to the new seismic provisions, had a minimum margin against collapse of 1.5 (BSSC, 2004)

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Maximum Considered Earthquake (MCE)

2% probability of exceedance in 50 years
(2,500 year return period)

Except in high seismic regions

Maximum Considered Earthquake (MCE)

2% probability of exceedance in 50 years
(2,500 year return period)

Except in high seismic regions → Deterministic

Basic Needs Of The Structural Engineer

- Mapped acceleration parameters (S_S and S_1)

Computing Response Spectra

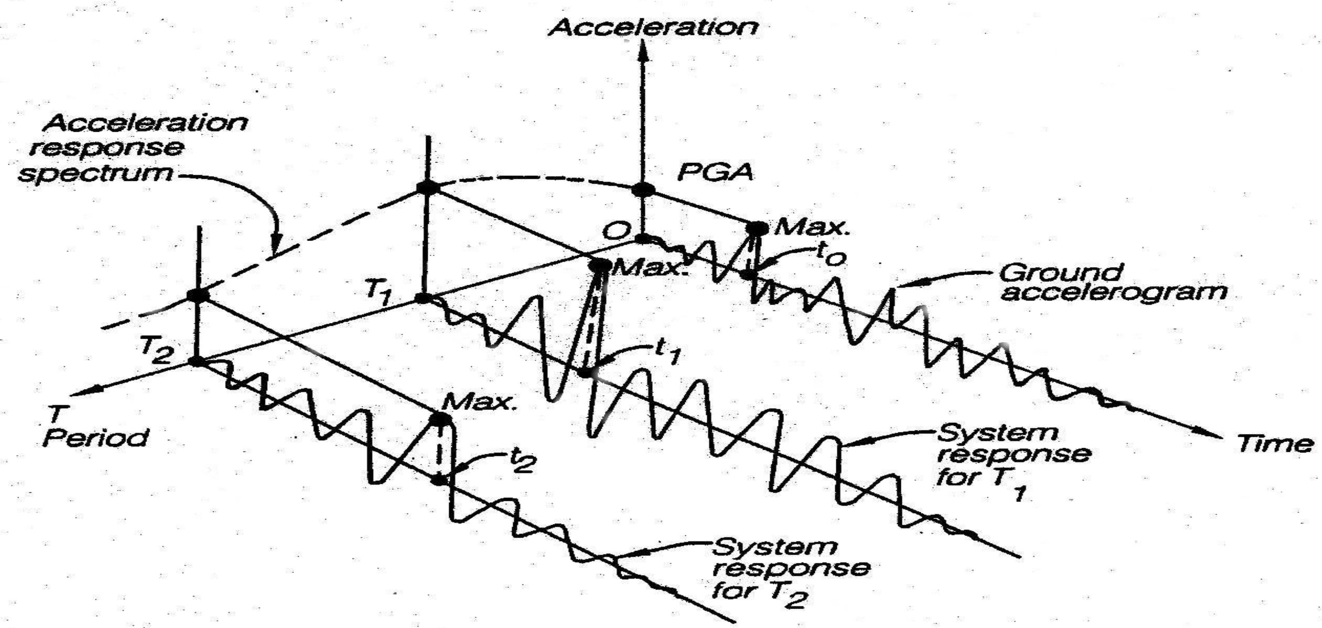

Figure 1 Acceleration Response spectrum

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Basic Needs Of The Structural Engineer

- Mapped acceleration parameters (S_S and S_1)
- Site class (A, B, C, D, E, or F)
- Long-period transition period (T_L)

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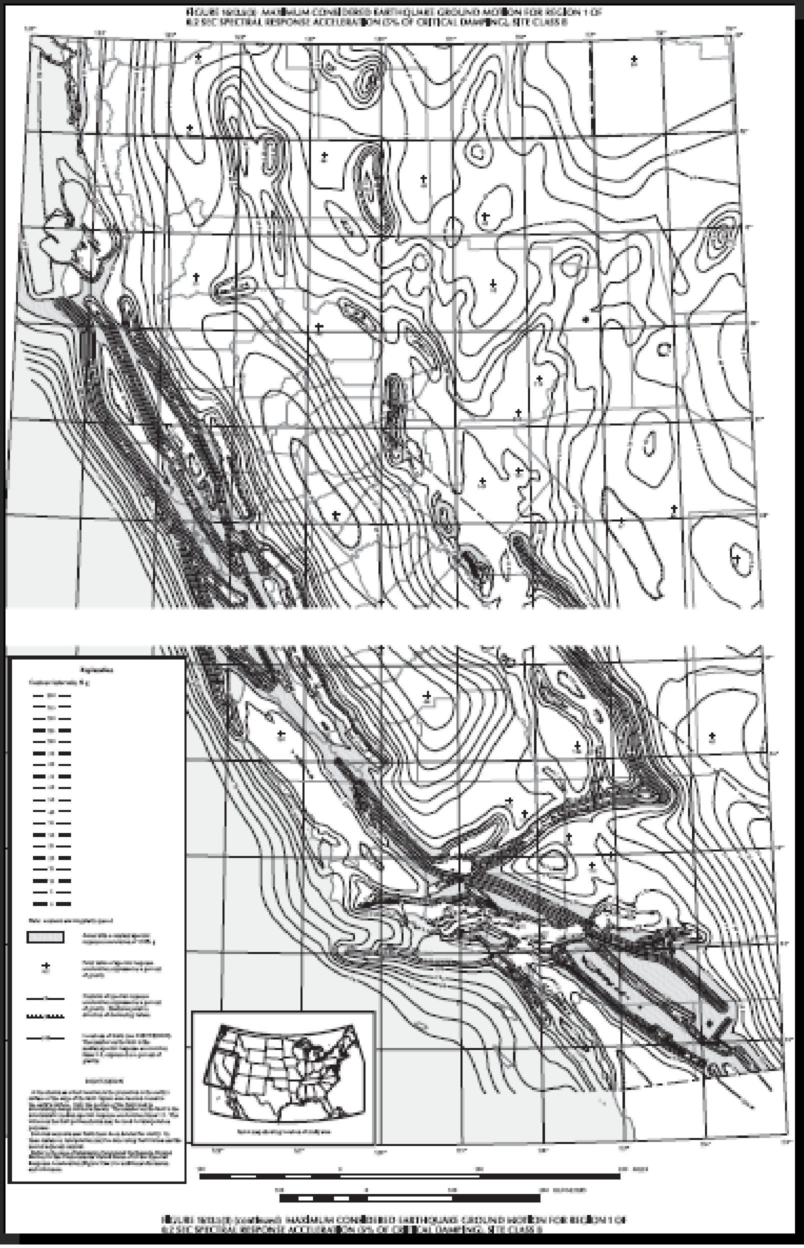
Mapped Acceleration Parameter S_S



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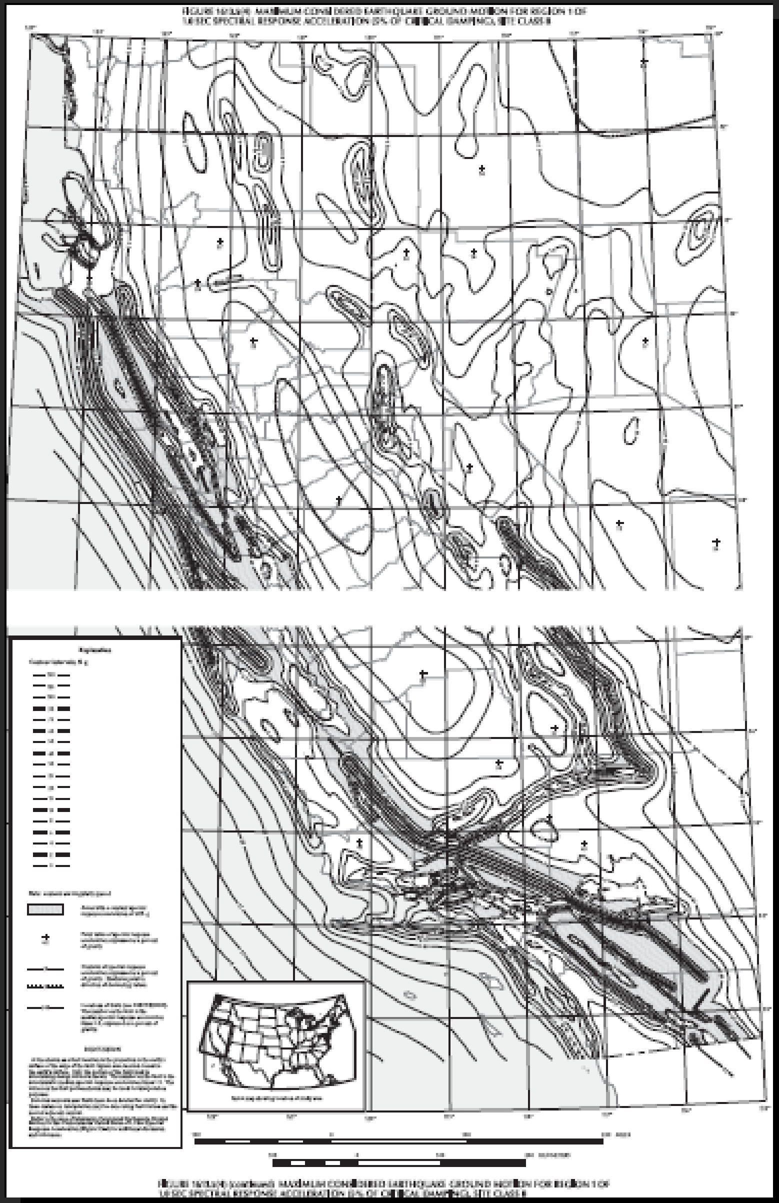
Mapped Acceleration Parameter S_1



Site Class Definitions

TABLE 1615.1.1
SITE CLASS DEFINITIONS

SITE CLASS	SOIL PROFILE NAME	AVERAGE PROPERTIES IN TOP 100 feet, AS PER SECTION 1615.1.5		
		Soil shear wave velocity, $\bar{v}_s$, (ft/s)	Standard penetration resistance, $\bar{N}$	Soil undrained shear strength, $\bar{s}_u$, (psf)
A	Hard rock	$\bar{v}_s > 5{,}000$	N/A	N/A
B	Rock	$2{,}500 < \bar{v}_s \leq 5{,}000$	N/A	N/A
C	Very dense soil and soft rock	$1{,}200 < \bar{v}_s \leq 2{,}500$	$\bar{N} > 50$	$\bar{s}_u \geq 2{,}000$
D	Stiff soil profile	$600 \leq \bar{v}_s \leq 1{,}200$	$15 \leq \bar{N} \leq 50$	$1{,}000 \leq \bar{s}_u \leq 2{,}000$
E	Soft soil profile	$\bar{v}_s < 600$	$\bar{N} < 15$	$\bar{s}_u < 1{,}000$
E	—	Any profile with more than 10 feet of soil having the following characteristics: 1. Plasticity index $PI > 20$, 2. Moisture content $w \geq 40\%$, and 3. Undrained shear strength $\bar{s}_u < 500$ psf		
F	—	Any profile containing soils having one or more of the following characteristics: 1. Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils. 2. Peats and/or highly organic clays ($H > 10$ feet of peat and/or highly organic clay where H = thickness of soil) 3. Very high plasticity clays ($H > 25$ feet with plasticity index $PI > 75$) 4. Very thick soft/medium stiff clays ($H > 120$ feet)		

For SI: 1 foot = 304.8 mm, 1 square foot = 0.0929 m^2, 1 pound per square foot = 0.0479 kPa. N/A = Not applicable

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Long-Period Transition Period T_L

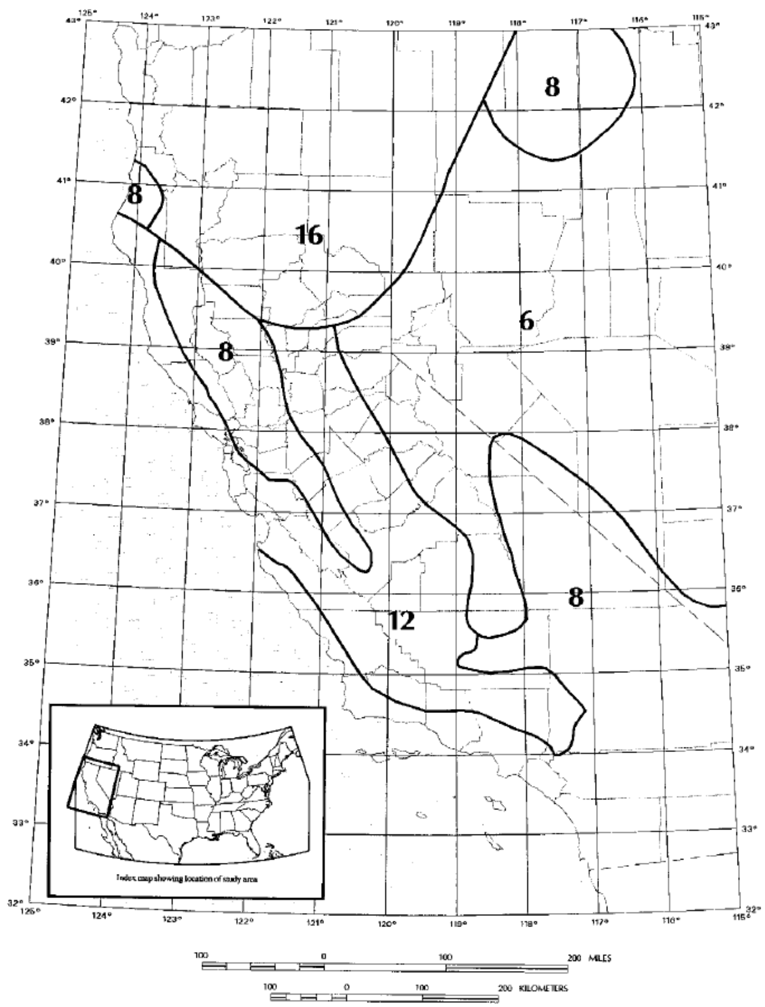

FIGURE 22-16 LONG-PERIOD TRANSITION PERIOD, T_L (SEC), FOR REGION 1

Spectral Acceleration Parameters

Maximum Considered Earthquake (MCE)

$$S_{MS} = F_a * S_S$$
$$S_{M1} = F_v * S_1$$

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Site Coefficients F_a and F_v

TABLE 1615.1.2(1)
VALUES OF SITE COEFFICIENT F_a AS A FUNCTION OF SITE CLASS AND MAPPED SPECTRAL RESPONSE ACCELERATION AT SHORT PERIODS (S_S)[a]

SITE CLASS	MAPPED SPECTRAL RESPONSE ACCELERATION AT SHORT PERIODS				
	$S_S \le 0.25$	$S_S = 0.50$	$S_S = 0.75$	$S_S = 1.00$	$S_S \ge 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	Note b	Note b	Note b	Note b	Note b

a. Use straight-line interpolation for intermediate values of mapped spectral response acceleration at short period, S_S.

b. Site-specific geotechnical investigation and dynamic site response analyses shall be performed to determine appropriate values, except that for structures with periods of vibration equal to or less than 0.5 second, values of F_a for liquefiable soils are permitted to be taken equal to the values for the site class determined without regard to liquefaction in Section 1615.1.5.1.

TABLE 1615.1.2(2)
VALUES OF SITE COEFFICIENT F_V AS A FUNCTION OF SITE CLASS AND MAPPED SPECTRAL RESPONSE ACCELERATION AT 1-SECOND PERIOD (S_1)[a]

SITE CLASS	MAPPED SPECTRAL RESPONSE ACCELERATION AT SHORT PERIODS				
	$S_1 \le 0.1$	$S_1 = 0.2$	$S_1 = 0.3$	$S_1 = 0.4$	$S_1 \ge 0.5$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	Note b	Note b	Note b	Note b	Note b

a. Use straight-line interpolation for intermediate values of mapped spectral response acceleration at 1-second period, S_1.

b. Site-specific geotechnical investigation and dynamic site response analyses shall be performed to determine appropriate values, except that for structures with periods of vibration equal to or less than 0.5 second, values of F_v for liquefiable soils are permitted to be taken equal to the values for the site class determined without regard to liquefaction in Section 1615.1.5.1.

Spectral Acceleration Parameters

Maximum Considered Earthquake (MCE)

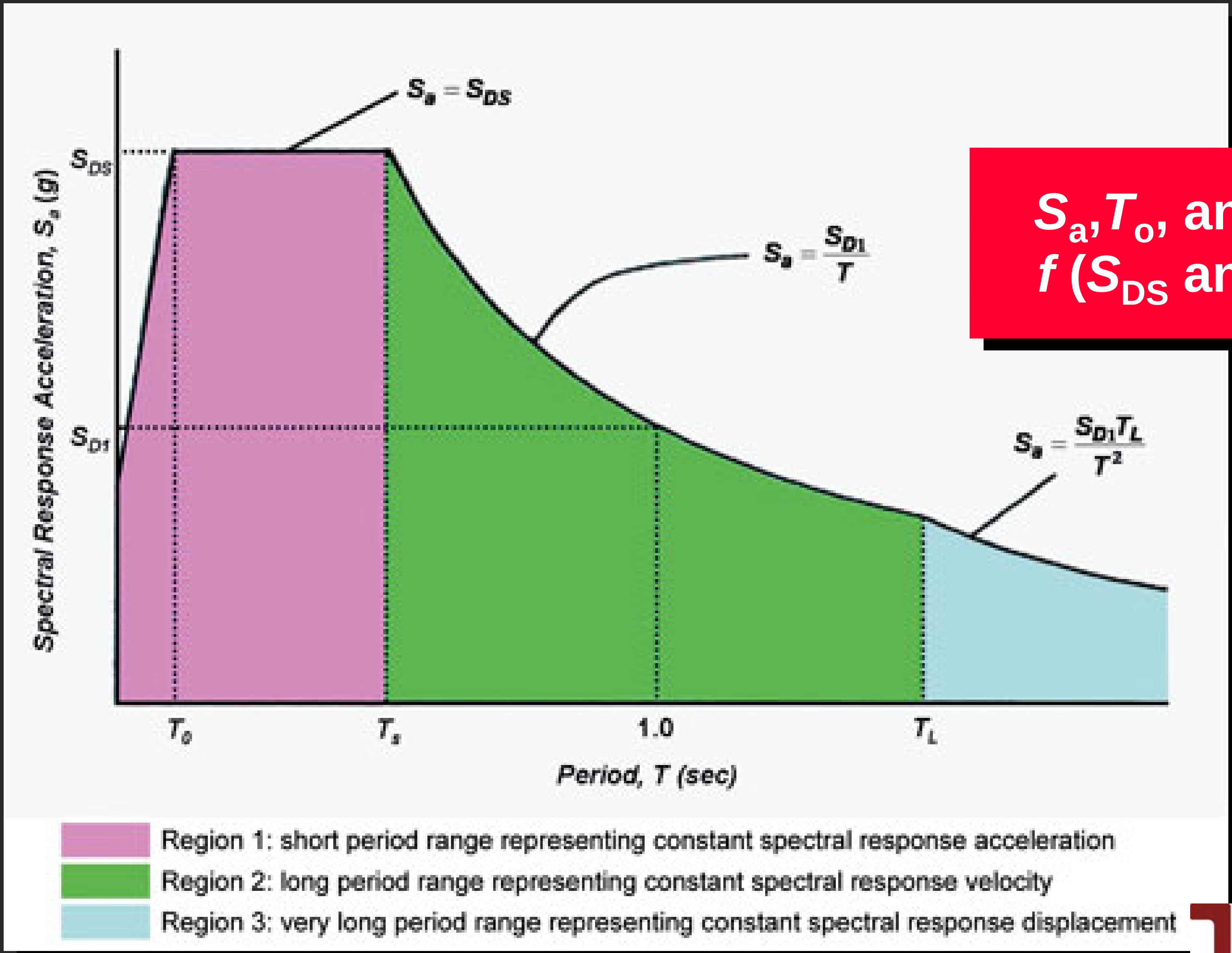
$$S_{MS} = F_a * S_S$$
$$S_{M1} = F_v * S_1$$

→

Design Earthquake

$$S_{DS} = 2/3 * S_{MS}$$
$$S_{D1} = 2/3 * S_{M1}$$

Design Response Spectrum



S_a, T_o, and T_S = f (S_{DS} and S_{D1})

Acceleration parameters, S_S and S_1 (Site Class B), from IBC maps

Acceleration parameters, S_S and S_1 (Site Class B), from IBC maps

Subsurface exploration (V_S, N, or S_u)

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Acceleration parameters, S_S and S_1 (Site Class B), from IBC maps

Subsurface exploration (V_S, N, or S_u)

Site class, A, B, C, D, E, or F, from Table 1613.5.2

Acceleration parameters, S_S and S_1 (Site Class B), from IBC maps

Subsurface exploration (V_S, N, or S_u)

Site class, A, B, C, D, E, or F, from Table 1613.5.2

Site coefficients, F_a and F_v, from Table 1613.5.3

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Acceleration parameters, S_S and S_1 (Site Class B), from IBC maps

Subsurface exploration (V_S, N, or S_u)

Site class, A, B, C, D, E, or F, from Table 1613.5.2

Site coefficients, F_a and F_v, from Table 1613.5.3

$$S_{MS} = F_a S_s$$
$$S_{M1} = F_v S_1$$

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Acceleration parameters, S_S and S_1 (Site Class B), from IBC maps

Subsurface exploration (V_S, N, or S_u)

Site class, A, B, C, D, E, or F, from Table 1613.5.2

Site coefficients, F_a and F_v, from Table 1613.5.3

$$S_{MS} = F_a S_s$$
$$S_{M1} = F_v S_1$$

$$S_{DS} = 2/3\, S_{MS}$$
$$S_{D1} = 2/3\, S_{M1}$$

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Acceleration parameters, S_S and S_1 (Site Class B), from IBC maps

Subsurface exploration (V_S, N, or S_u)

Site class, A, B, C, D, E, or F, from Table 1613.5.2

Site coefficients, F_a and F_v, from Table 1613.5.3

$$S_{MS} = F_a S_s$$
$$S_{M1} = F_v S_1$$

$$S_{DS} = 2/3\ S_{MS}$$
$$S_{D1} = 2/3\ S_{M1}$$

Long-period transition period, T_L, from Fig. 22-16 (ASCE 7)

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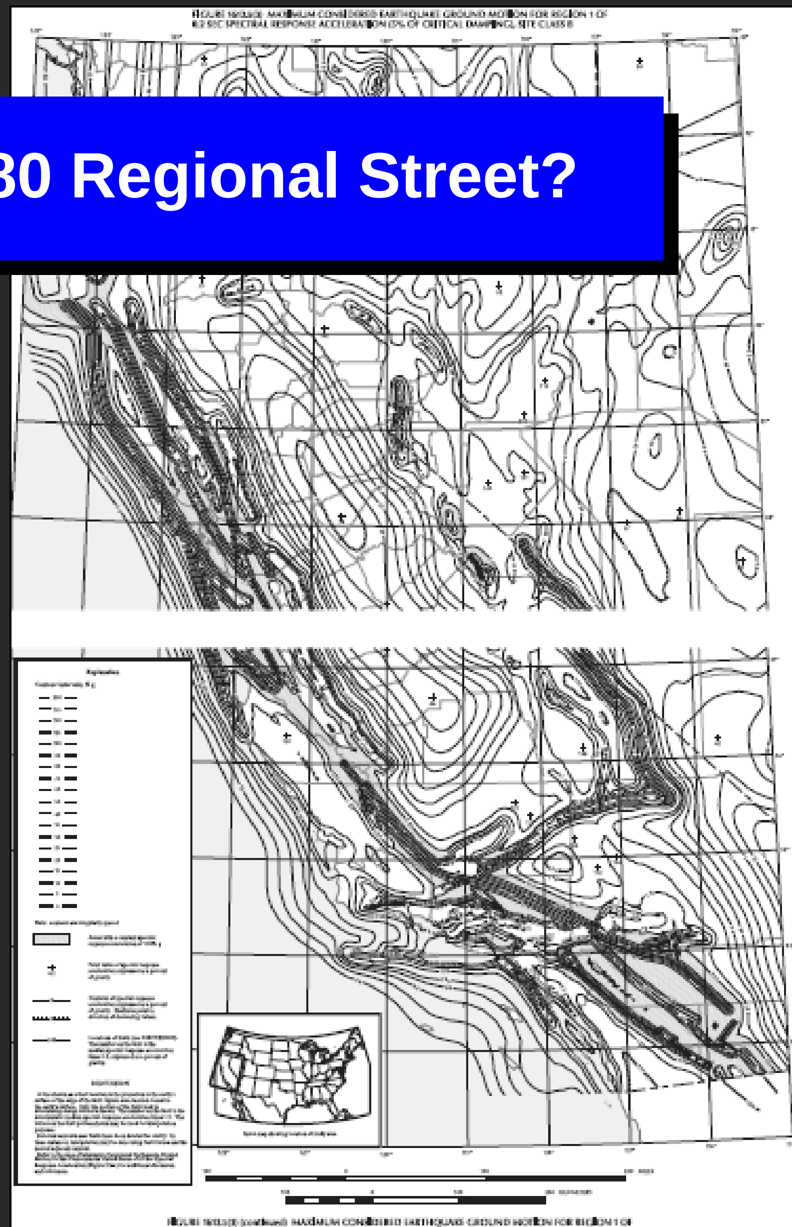
Example Project

- 3-story hotel
- 6680 Regional Street, Dublin, CA

IBC Short Period Spectral Acceleration



6680 Regional Street?

IBC Short Period Spectral Acceleration

6680 Regional Street

37.702N
121.933W

http://terraserver.microsoft.com

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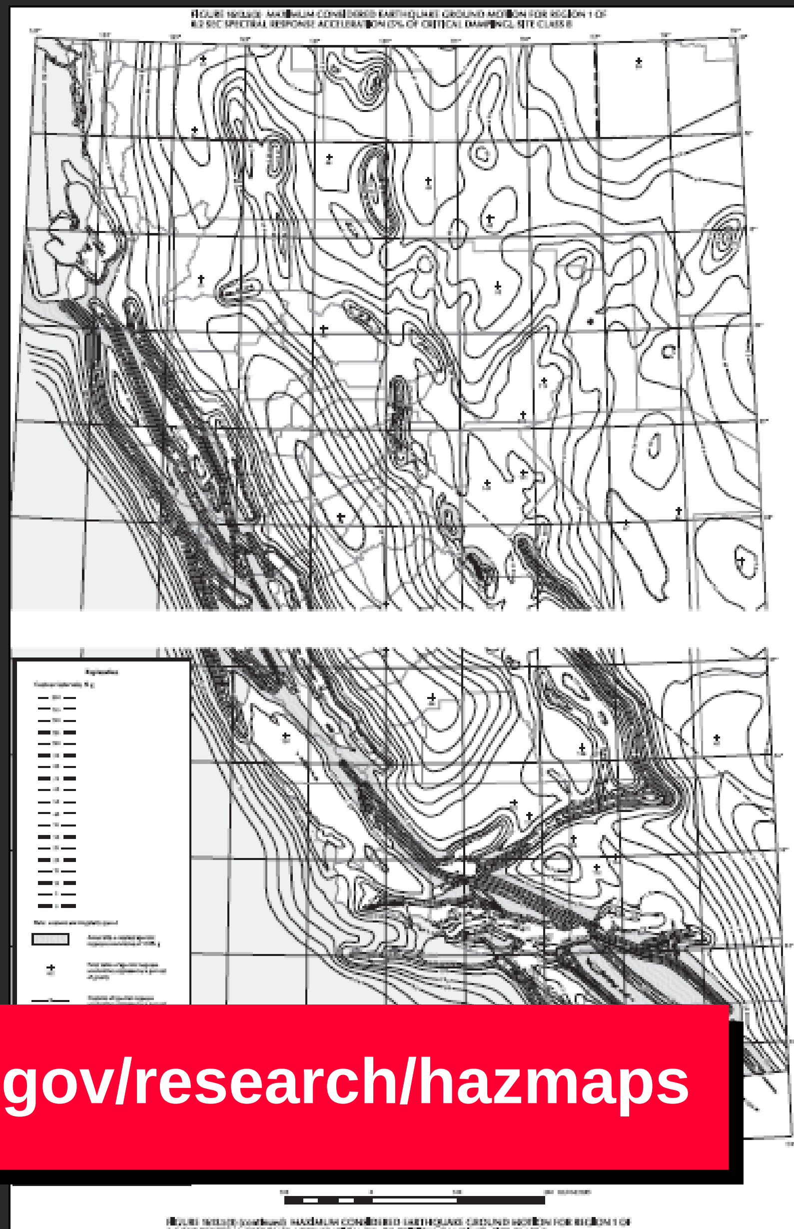
IBC Short Period Spectral Acceleration



http://earthquake.usgs.gov/research/hazmaps

Earthquake Hazards Program

National & Regional Seismic Hazard Maps

The USGS provides seismic hazard assessments for the U.S. and areas around the world. These hazard maps serve as the basis for seismic provisions used in building codes and influence billions of dollars of new construction every year. Learn more about seismic hazard analysis, the USGS maps, the underlying data, and the resulting building codes by browsing the links below.

Seismic Hazard Maps

US National and Regional Probabilistic Ground Motion Maps, Input and Output Data, and Documentation. Conterminous US , Alaska, Hawaii, Puerto Rico. **US Urban Maps and International Maps** Fault Database. Compare the seismic hazard in your area with other parts of the US and the world.

Custom Mapping and Analysis Tools

Interactive Mapping, Hazard Value Lookup, Deaggregations, Earthquake Probability Mapping, Hazard Computer Codes.

Re-plot USGS probabilistic hazard maps for your area of interest, get hazard values using latitude/longitude or zip code, find predominant magnitudes and distances, map probability of given magnitude within a certain distance from a site.

Seismic Design Values for Buildings

Ss and S1, Hazard Curves, Uniform Hazard Spectra, and Residential Seismic Design Category Maps.

Find site design ground motion values for various building codes, using latitude/longitude or zip codes. Display and download hazard curve or uniform hazard spectrum for a site. Access seismic design maps. Learn about the process of incorporating seismic hazards into building codes.

Earthquake Hazards 101

The basics, Easy Access to Maps and Faults, FAQ's

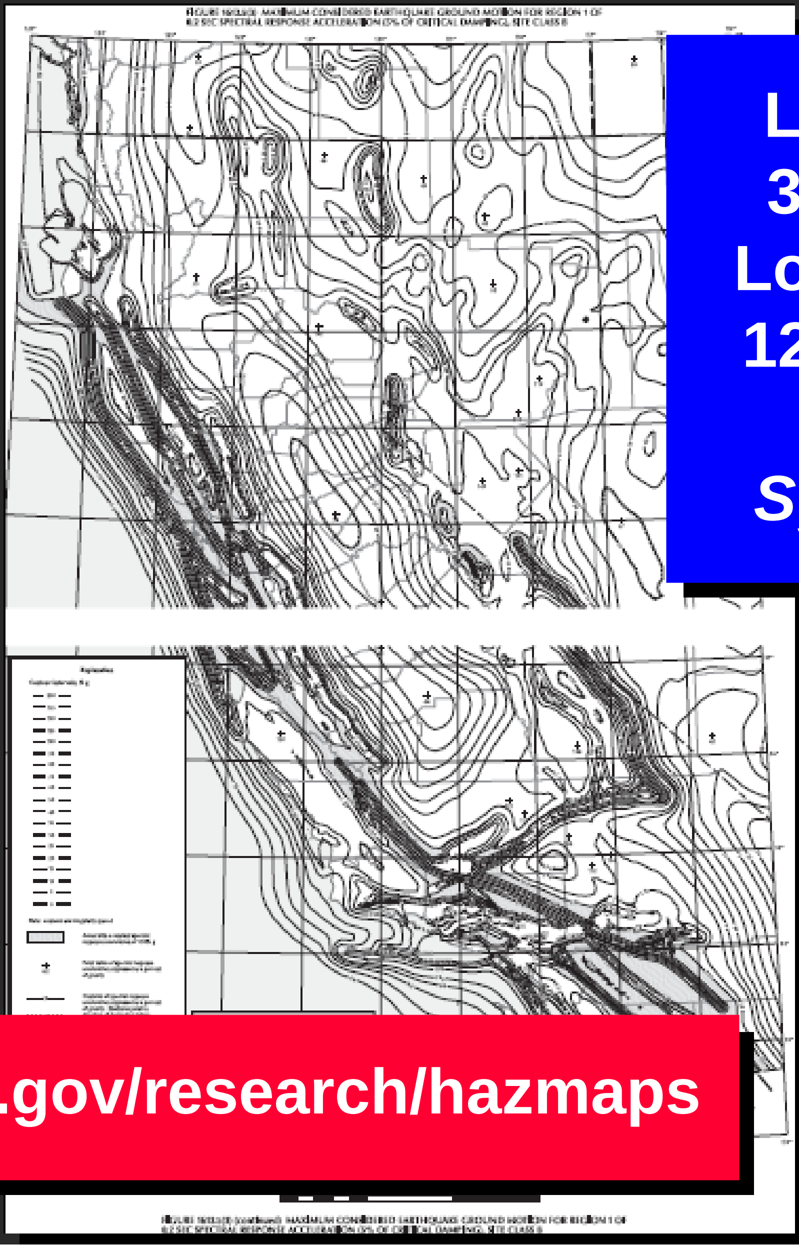
The concepts behind earthquake hazard maps: why use probability, what the maps mean, and how they are made. Easier access to hazard maps and faults. Answers to frequently asked questions.

Project and Workshop Information

Personnel, Project Publications, Upcoming Workshops Schedule, Notification Mailing List.

Browse project bibliography, view or download technical publications on seismic hazard analysis, see schedule for upcoming workshops and future map revisions.

IBC Short Period Spectral Acceleration

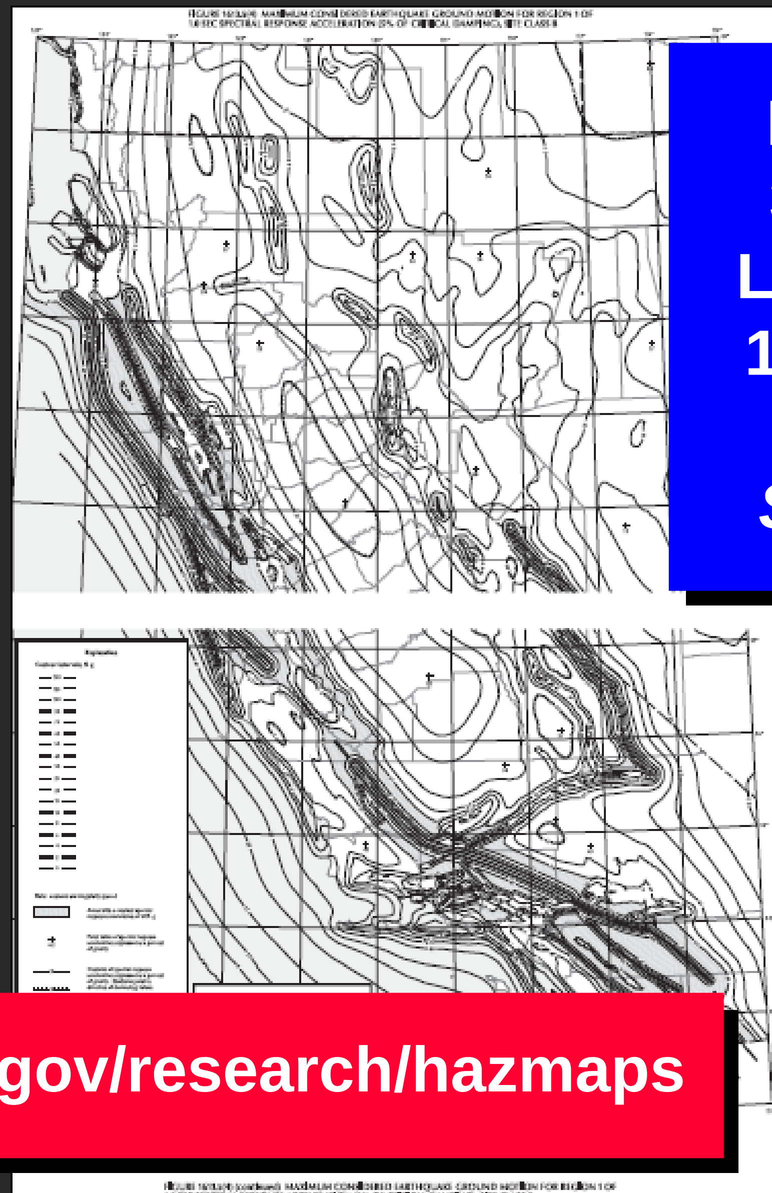


Latitude
37.702N
Longitude
121.933W

S_S = 2.71

http://earthquake.usgs.gov/research/hazmaps

IBC 1-Second Period Spectral Acceleration



Latitude
37.702N
Longitude
121.933W

S_1 **= 1.06**

http://earthquake.usgs.gov/research/hazmaps

Site Class Definitions

TABLE 1615.1.1
SITE CLASS DEFINITIONS

SITE CLASS	SOIL PROFILE NAME	AVERAGE PROPERTIES IN TOP 100 feet, AS PER SECTION 1615.1.5		
		Soil shear wave velocity, $\bar{v}_s$, (ft/s)	Standard penetration resistance, $\bar{N}$	Soil undrained shear strength, $\bar{s}_u$, (psf)
A	Hard rock	$\bar{v}_s > 5{,}000$	N/A	N/A
B	Rock	$2{,}500 < \bar{v}_s \leq 5{,}000$	N/A	N/A
C	Very dense soil and soft rock	$1{,}200 < \bar{v}_s \leq 2{,}500$	$\bar{N} > 50$	$\bar{s}_u \geq 2{,}000$
D	Stiff soil profile	$600 \leq \bar{v}_s \leq 1{,}200$	$15 \leq \bar{N} \leq 50$	$1{,}000 \leq \bar{s}_u \leq 2{,}000$
E	Soft soil profile	$\bar{v}_s < 600$	$\bar{N} < 15$	$\bar{s}_u < 1{,}000$
E	—	Any profile with more than 10 feet of soil having the following characteristics: 1. Plasticity index $PI > 20$, 2. Moisture content $w \geq 40\%$, and 3. Undrained shear strength $\bar{s}_u < 500$ psf		
F	—	Any profile containing soils having one or more of the following characteristics: 1. Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils. 2. Peats and/or highly organic clays ($H > 10$ feet of peat and/or highly organic clay where H = thickness of soil) 3. Very high plasticity clays ($H > 25$ feet with plasticity index $PI > 75$) 4. Very thick soft/medium stiff clays ($H > 120$ feet)		

For SI: 1 foot = 304.8 mm, 1 square foot = 0.0929 m^2, 1 pound per square foot = 0.0479 kPa. N/A = Not applicable

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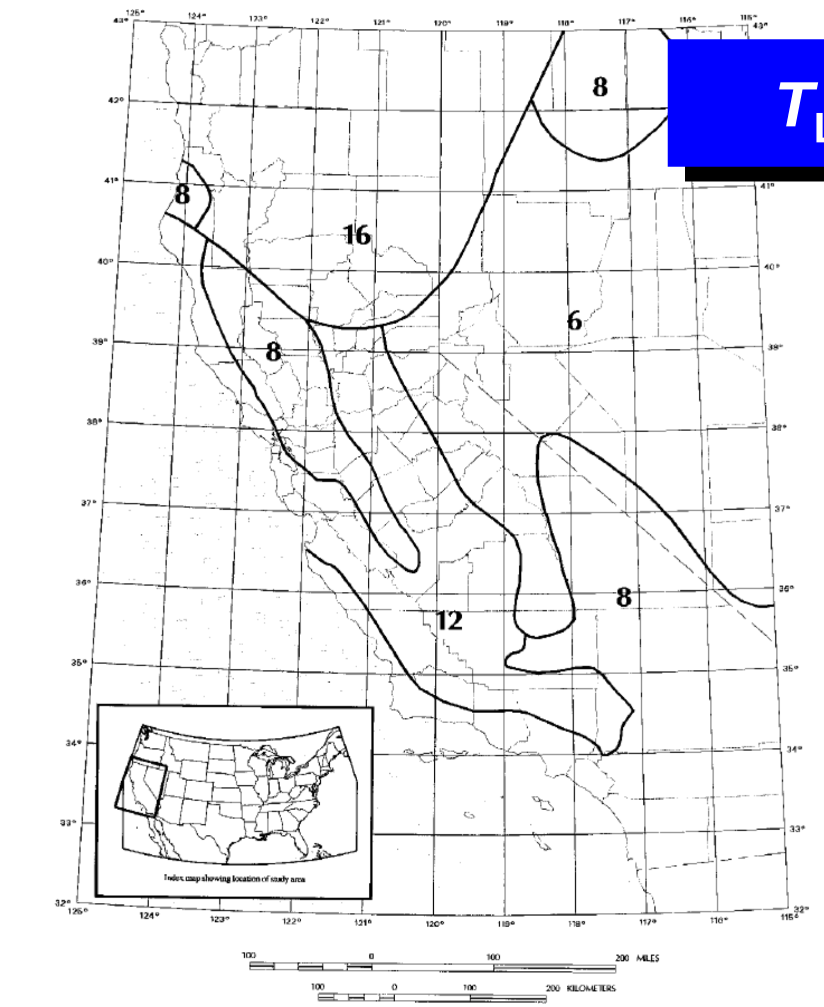
Long-Period Transition Period T_L



T_L = 8

FIGURE 22-16 LONG-PERIOD TRANSITION PERIOD, T_L (SEC), FOR REGION 1

Basic Needs Of The Structural Engineer

- Mapped acceleration parameters
  S_S = 2.71 and S_1 = 1.06

- Site class D

- Long-period transition period
  T_L = 8

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IBC Site Coefficients F_a and F_v

TABLE 1615.1.2(1)
VALUES OF SITE COEFFICIENT F_a AS A FUNCTION OF SITE CLASS AND MAPPED SPECTRAL RESPONSE ACCELERATION AT SHORT PERIODS (S_S)[a]

SITE CLASS	MAPPED SPECTRAL RESPONSE ACCELERATION AT SHORT PERIODS				
	$S_S \le 0.25$	$S_S = 0.50$	$S_S = 0.75$	$S_S = 1.00$	$S_S \ge 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	Note b	Note b	Note b	Note b	Note b

a. Use straight-line interpolation for intermediate values of mapped spectral response acceleration at short period, S_s.
b. Site-specific geotechnical investigation and dynamic site response analyses shall be performed to determine appropriate values, except that for structures with periods of vibration equal to or less than 0.5 second, values of F_a for liquefiable soils are permitted to be taken equal to the values for the site class determined without regard to liquefaction in Section 1615.1.5.1.

TABLE 1615.1.2(2)
VALUES OF SITE COEFFICIENT F_v AS A FUNCTION OF SITE CLASS AND MAPPED SPECTRAL RESPONSE ACCELERATION AT 1-SECOND PERIOD (S_1)[a]

SITE CLASS	MAPPED SPECTRAL RESPONSE ACCELERATION AT SHORT PERIODS				
	$S_1 \le 0.1$	$S_1 = 0.2$	$S_1 = 0.3$	$S_1 = 0.4$	$S_1 \ge 0.5$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	Note b	Note b	Note b	Note b	Note b

a. Use straight-line interpolation for intermediate values of mapped spectral response acceleration at 1-second period, S_1.
b. Site-specific geotechnical investigation and dynamic site response analyses shall be performed to determine appropriate values, except that for structures with periods of vibration equal to or less than 0.5 second, values of F_v for liquefiable soils are permitted to be taken equal to the values for the site class determined without regard to liquefaction in Section 1615.1.5.1.

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Spectral Acceleration Parameters

Maximum Considered Earthquake (MCE)

$$S_{MS} = F_a * S_S$$
$$S_{M1} = F_v * S_1$$

Spectral Acceleration Parameters

Maximum Considered Earthquake (MCE)

S_{MS} = 1.0 * 2.71 = 2.71
S_{M1} = 1.5 * 1.06 = 1.59

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Spectral Acceleration Parameters

Maximum Considered Earthquake (MCE)

S_{MS} = 2.71
S_{M1} = 1.59

→

Design Earthquake

$S_{DS} = 2/3 * S_{MS}$
$S_{D1} = 2/3 * S_{M1}$

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Spectral Acceleration Parameters

Maximum Considered Earthquake (MCE)

S_{MS} = 2.71
S_{M1} = 1.59

→

Design Earthquake

S_{DS} = 2/3 * 2.71 = 1.81
S_{D1} = 2/3 * 1.59 = 1.06

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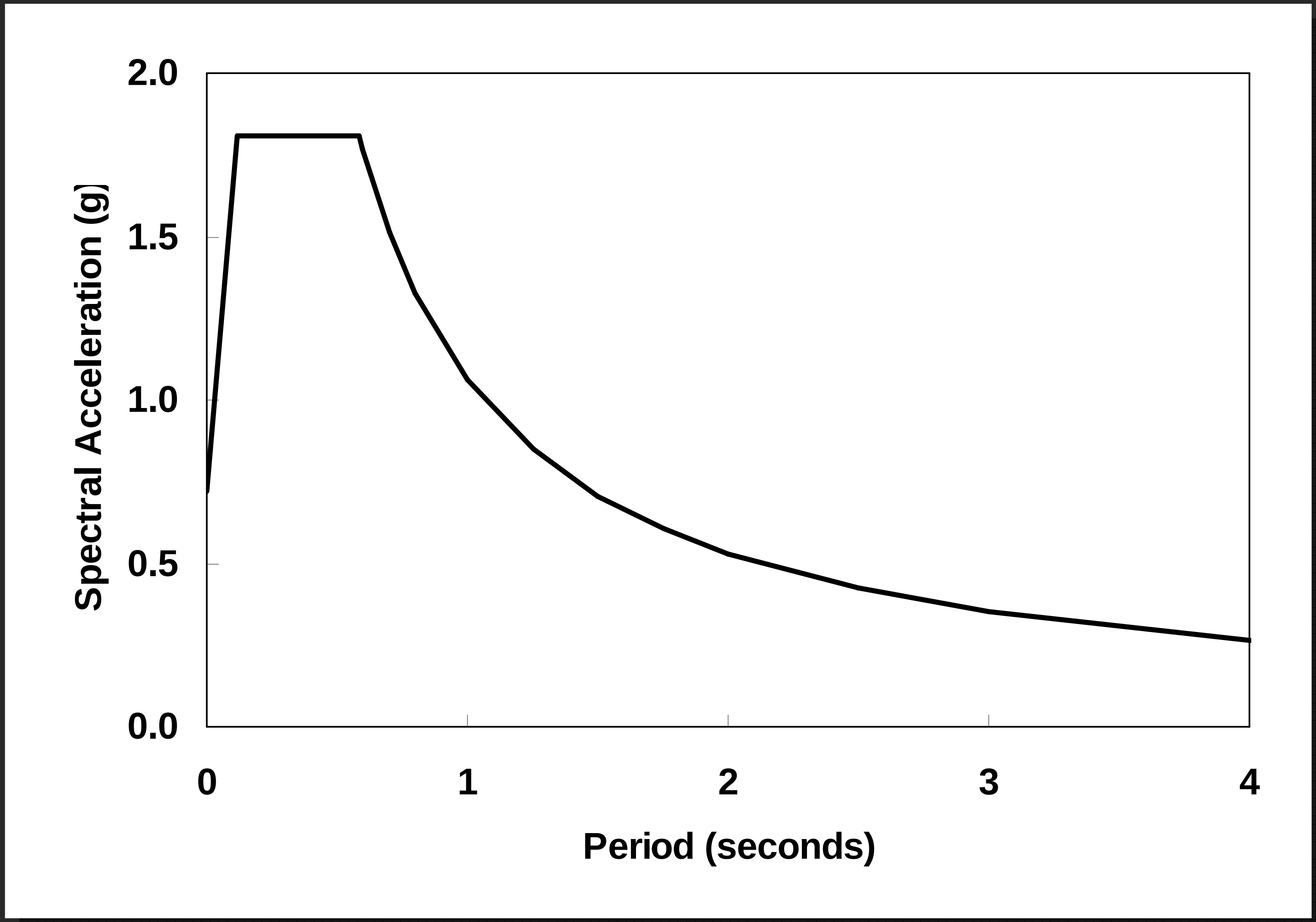
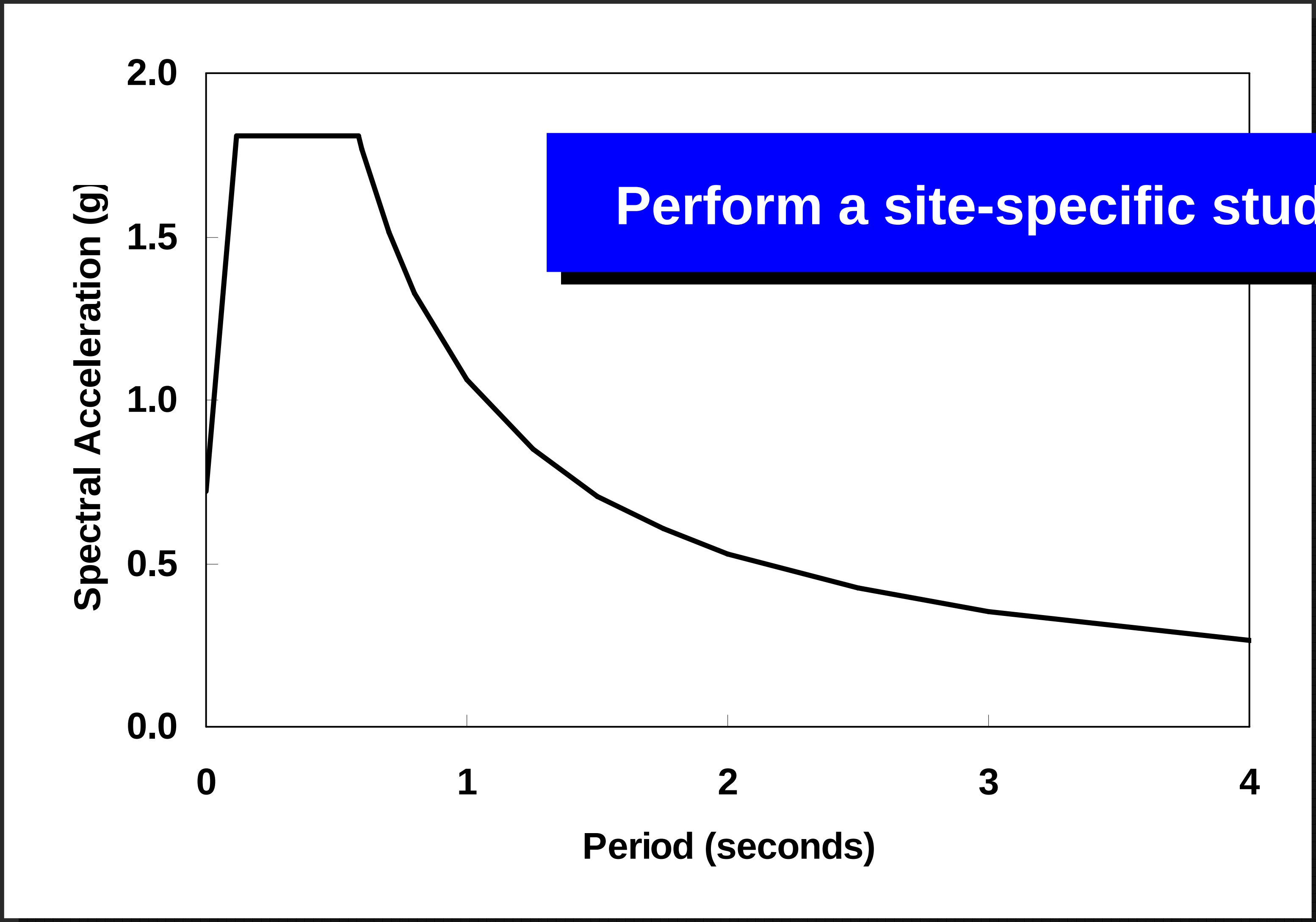
Design Response Spectrum

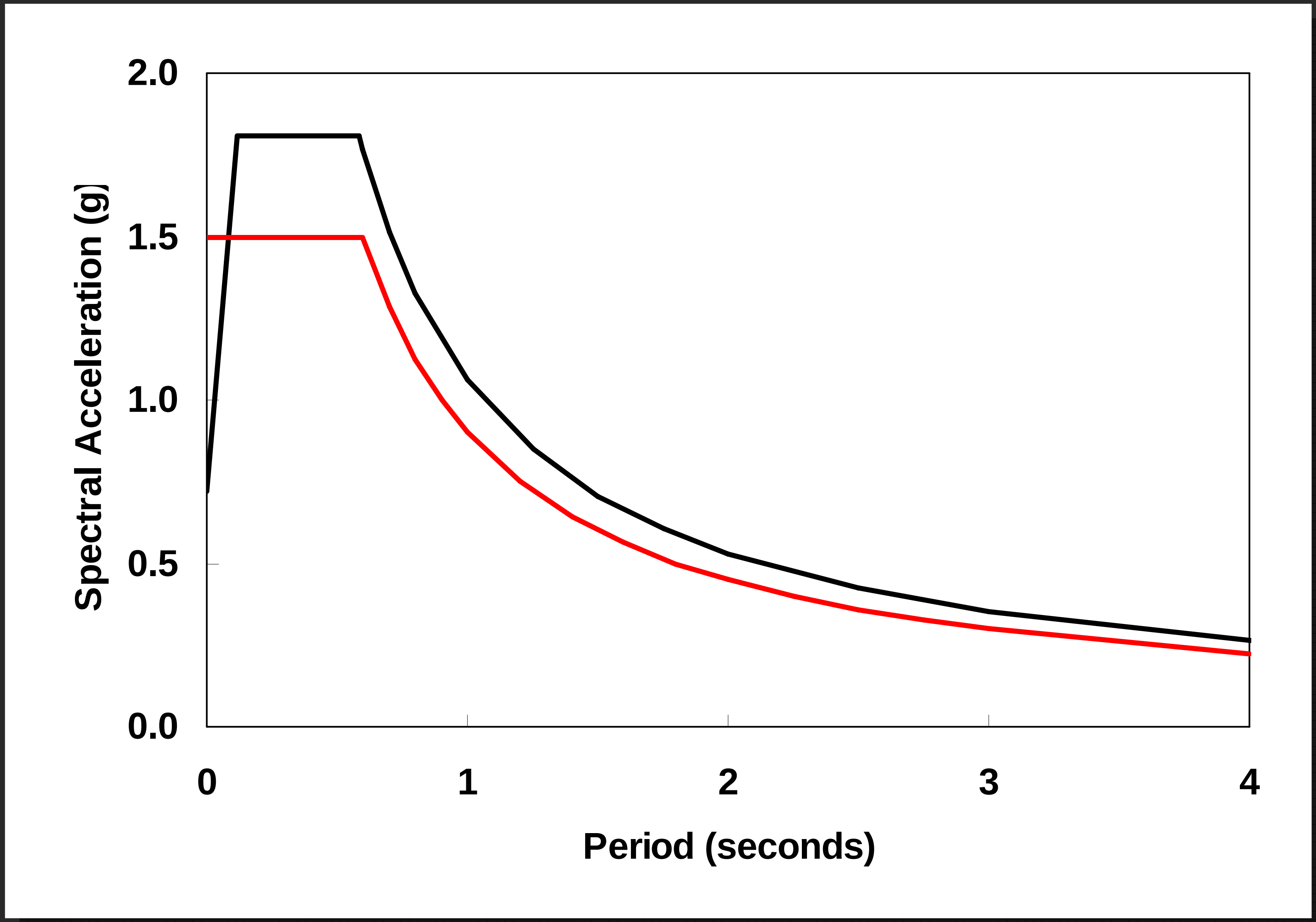


Design Response Spectrum

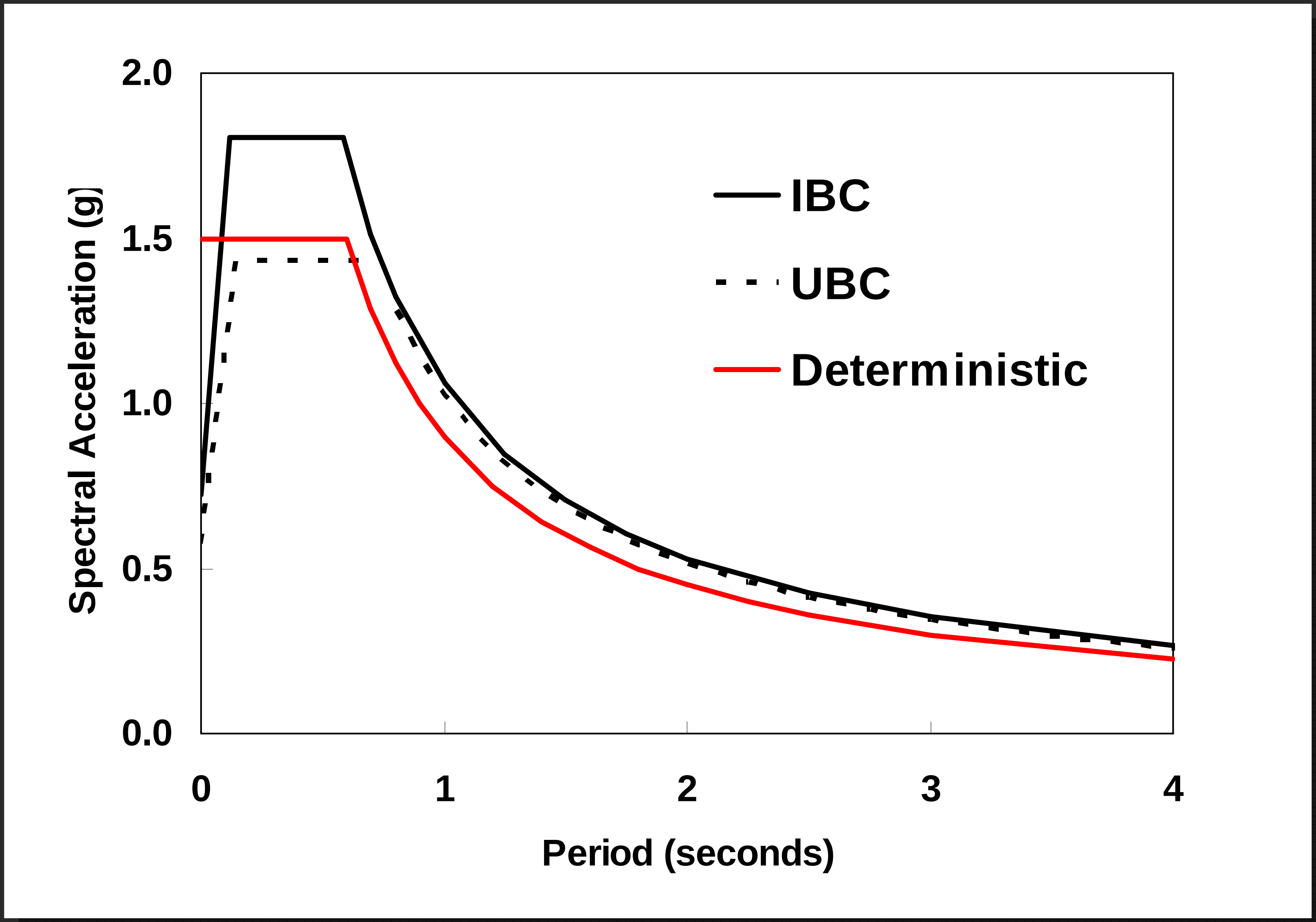


Perform a site-specific study

Design Response Spectrum



Design Spectrum



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Site-Specific Study Required

- Base isolated structures
- Structures with damping systems on sites with $S_1 \geq 0.6$
- Site class F, except for $T \leq 0.5$ second structures

Site-Specific Study Alternatives

- Attenuation relations (not for site class F)
- Site response analysis

Also,

- Probabilistic
- Deterministic

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Site-Specific Study Limitations/Requirements

- Site response input motions
- Spectral values not less than 80 percent of general procedure
- $S_{DS} \geq 0.9\ S_a$ and $S_{D1} \geq 2 * S_a$ at T = 2 seconds
- Deterministic limit

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Deterministic Limit

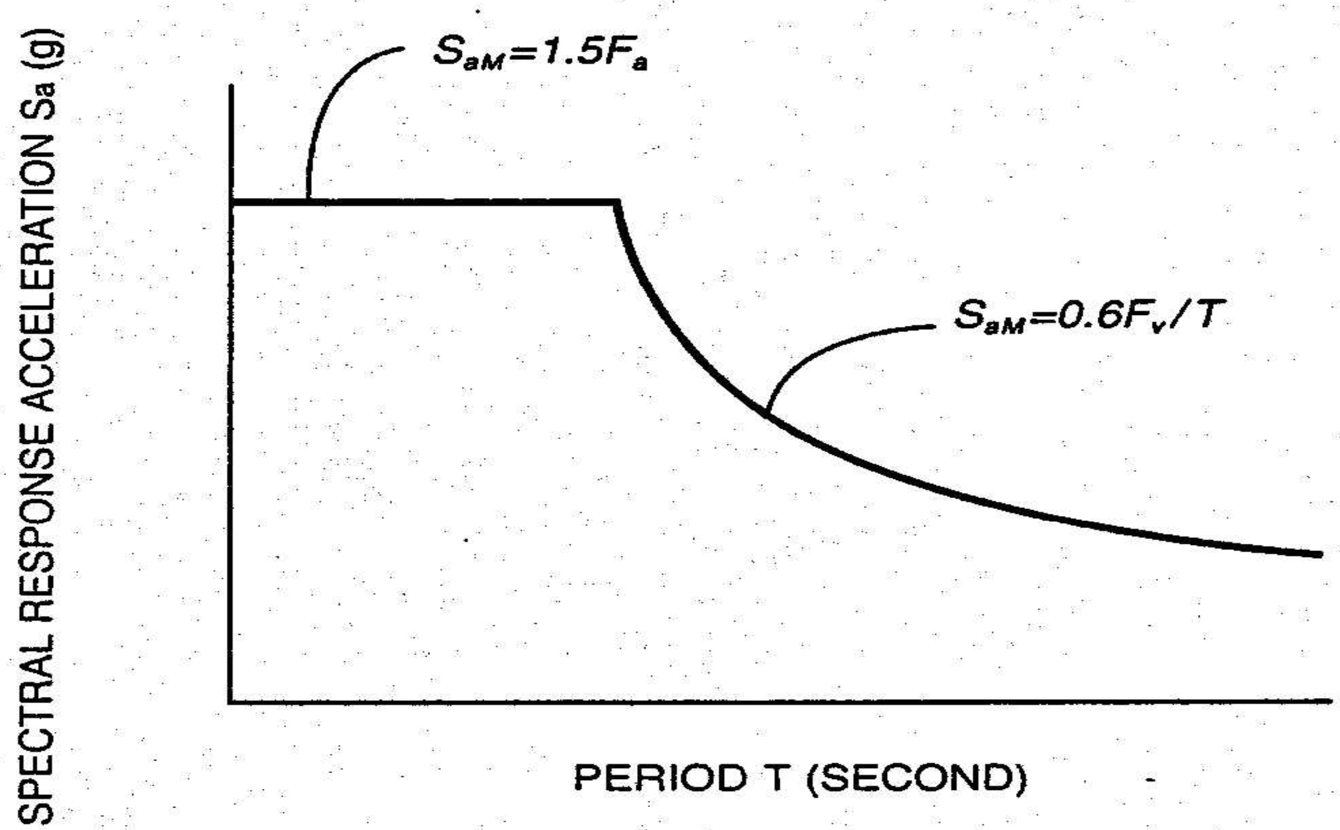

FIGURE 1615.2.2
DETERMINISTIC LIMIT ON MAXIMUM CONSIDERED EARTHQUAKE RESPONSE SPECTRUM

MCE ?’s

What Else Does The Geotech Need to Address?

- Slope instability
- Liquefaction (strength loss and settlement)
- Lateral spreading
- Fault rupture
- Mitigation measures
- Dynamic earth pressures on walls
- Kinematic loads (SSI) on deep foundations

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Ground Motion Parameters

- Source characteristics and ground motion values consistent with design earthquake
- PGA from site-specific study, or $S_{DS}/2.5$

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Earthquake Hazards Program

National & Regional Seismic Hazard Maps

The USGS provides seismic hazard assessments for the U.S. and areas around the world. These hazard maps serve as the basis for seismic provisions used in building codes and influence billions of dollars of new construction every year. Learn more about seismic hazard analysis, the USGS maps, the underlying data, and the resulting building codes by browsing the links below.

Seismic Hazard Maps

US National and Regional Probabilistic Ground Motion Maps, Input and Output Data, and Documentation. Conterminous US , Alaska, Hawaii, Puerto Rico. **US Urban Maps and International Maps** Fault Database. Compare the seismic hazard in your area with other parts of the US and the world.

Custom Mapping and Analysis Tools

Interactive Mapping, Hazard Value Lookup, Deaggregations, Earthquake Probability Mapping, Hazard Computer Codes.

Re-plot USGS probabilistic hazard maps for your area of interest, get hazard values using latitude/longitude or zip code, find predominant magnitudes and distances, map probability of given magnitude within a certain distance from a site.

Seismic Design Values for Buildings

Ss and S1, Hazard Curves, Uniform Hazard Spectra, and Residential Seismic Design Category Maps.

Find site design ground motion values for various building codes, using latitude/longitude or zip codes. Display and download hazard curve or uniform hazard spectrum for a site. Access seismic design maps. Learn about the process of incorporating seismic hazards into building codes.

Earthquake Hazards 101

The basics, Easy Access to Maps and Faults, FAQ's

The concepts behind earthquake hazard maps: why use probability, what the maps mean, and how they are made. Easier access to hazard maps and faults. Answers to frequently asked questions.

Project and Workshop Information

Personnel, Project Publications, Upcoming Workshops Schedule, Notification Mailing List.

Browse project bibliography, view or download technical publications on seismic hazard analysis, see schedule for upcoming workshops and future map revisions.

Site name:

Used for plot labeling purposes only
underscore (_), comma (,) and
alphanumeric characters only,
no blanks (they will be replaced with an underscore),
name length <= 16 characters.
Name: Dublin

Select location of interest in latitude/longitude:

Specify in decimal degrees, use "-" to specify western longitudes.
Conterminous US: latitude 25 to 49 degrees, longitude -125 to -65 degrees, only.
Alaska: refer to 1996 Interactive Deaggregations page.
Hawaii: refer to 1996 Interactive Deaggregations page.
Puerto Rico: latitude 17 to 19 degrees, longitude -64 to -68 degrees, only.
Latitude: 37.702 Longitude: -121.933

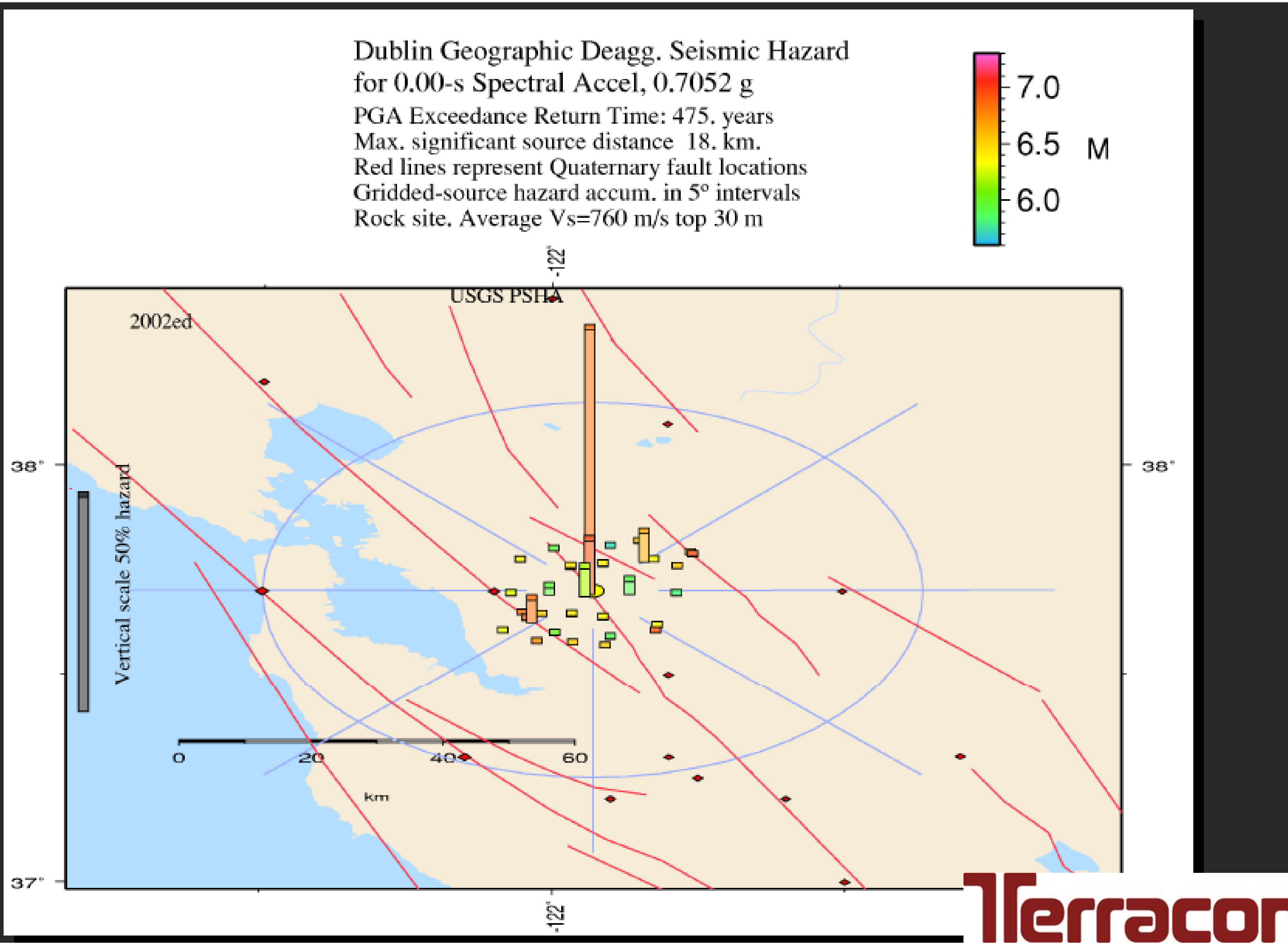
Return time:

PE = probability of exceedance
Select one!
1% PE in 50 years
2% PE in 50 years
5% PE in 50 years
10% PE in 50 yrs

SA frequency:

SA = Spectral Acceleration;
PGA = peak ground acceleration.
Puerto Rico: only 0.5 hz, 1.0 hz, 5.0 hz and PGA are available

Terracon


Dublin Geographic Deagg. Seismic Hazard
for 0.00-s Spectral Accel, 0.7052 g
PGA Exceedance Return Time: 475. years
Max. significant source distance 18. km.
Red lines represent Quaternary fault locations
Gridded-source hazard accum. in 5° intervals
Rock site. Average Vs=760 m/s top 30 m
7.0
6.5
6.0
M
USGS PSHA
2002ed
-122°
38°
37°
Vertical scale 50% hazard
0
20
40
60
km
Terracon

*** Deaggregation of Seismic Hazard for PGA & 2 Periods of Spectral Accel. ***
*** Data from U.S.G.S. National Seismic Hazards Mapping Project, 2002 version ***
PSHA Deaggregation. %contributions. site: Santa_Ana long: 117.853 W., lat: 33.709 N.
USGS 2002-03 update files and programs. dM=0.2. Site descr:ROCK
Return period: 2475 yrs. Exceedance PGA =0.6197 g.
#Pr[at least one eq with median motion>=PGA in 50 yrs]=0.00620

DIST(KM)	MAG(MW)	ALL_EPS	EPSILON>2	1<EPS<2	0<EPS<1	-1<EPS<0	-2<EPS<-1	EPS<-2
7.0	5.05	1.376	1.079	0.298	0.000	0.000	0.000	0.000
13.0	5.05	0.157	0.157	0.000	0.000	0.000	0.000	0.000
7.0	5.20	2.749	1.770	0.979	0.000	0.000	0.000	0.000
13.1	5.20	0.412	0.412	0.000	0.000	0.000	[illegible]	[illegible]
7.0	5.40	2.755	1.341	1.414	0.000	0.000	[illegible]	[illegible]
13.3	5.40	0.540	0.540	0.000	0.000	0.000	[illegible]	[illegible]
7.0	5.60	2.759	0.999	1.760	0.000	0.000	[illegible]	[illegible]
13.5	5.60	0.695	0.695	0.000	0.000	0.000	[illegible]	[illegible]
7.0	5.80	2.725	0.740	1.961	0.025	0.000	[illegible]	[illegible]
13.7	5.80	0.857	0.829	0.027	0.000	0.000	[illegible]	[illegible]
6.6	6.02	3.785	0.814	2.499	0.472	0.000	[illegible]	[illegible]
13.2	6.01	1.039	0.823	0.216	0.000	0.000	[illegible]	[illegible]
5.9	6.23	8.051	1.082	4.309	2.661	0.000	[illegible]	[illegible]
13.1	6.20	1.214	0.788	0.426	0.000	0.000	[illegible]	[illegible]
4.0	6.44	28.962	1.798	9.554	13.929	3.681	[illegible]	[illegible]
12.2	6.41	1.686	0.753	0.932	0.000	0.000	0.000	0.000
21.5	6.38	0.059	0.059	0.000	0.000	0.000	0.000	0.000
4.2	6.64	21.023	1.285	7.335	9.736	2.667	0.000	0.000
13.2	6.62	1.756	0.972	0.783	0.000	0.000	0.000	0.000
22.2	6.61	0.071	0.071	0.000	0.000	0.000	0.000	0.000
4.8	6.83	5.645	0.348	2.125	2.656	0.516	0.000	0.000
13.4	6.83	4.188	2.366	1.823	0.000	0.000	0.000	0.000
23.2	6.82	0.107	0.107	0.000	0.000	0.000	0.000	0.000
7.4	6.95	1.430	0.150	0.820	0.460	0.000	0.000	0.000
13.5	7.03	3.728	2.514	1.214	0.000	0.000	0.000	0.000
23.8	7.01	0.090	0.090	0.000	0.000	0.000	0.000	0.000
13.0	7.21	1.905	0.817	1.088	0.000	0.000	0.000	0.000
13.3	7.42	0.126	0.049	0.077	0.000	0.000	0.000	0.000

10% in 50 year

PGA = 0.71g

Summary statistics for above PSHA PGA deaggregation, R=distance, e=epsilon:
Mean src-site R= 6.5 km; M= 6.38; eps0= 0.67. Mean calculated for all sources.
Modal src-site R= 4.0 km; M= 6.44; eps0= 0.01 from peak (R,M) bin
Gridded source distance metrics: Rseis Rrup and Rjb
MODE R*= 3.9km; M*= 6.45; EPS.INTERVAL: 0 to 1 sigma % CONTRIB.= 13.929

Principal sources (faults, subduction, random seismicity having >10% contribution)

Source Category:	% contr.	R(km)	M	epsilon0 (mean values)
Calif. thrust/reverse faults	45.34	3.6	6.54	-0.14
California shallow gridded	45.14	8.0	6.10	1.26
Individual fault hazard details if contrib.>1%:				
2 Newport-Inglewood offshore	3.43	14.3	7.02	1.90
2 Newport-Inglewood	4.25	12.4	7.02	1.63
2 Newport-Inglewood GR M-distri	1.32	13.1	6.79	1.80
2 San Joaquin Hills Thrust	28.65	3.5	6.56	-0.16
2 San Joaquin Hills Thrust GR M	16.53	3.5	6.51	-0.14

```
Summary statistics for above PSHA PGA  deaggregation, R=distance, e=epsilon:
 Mean src-site R=    2.5 km; M= 6.73; eps0=   0.37. Mean calculated for all
sources.
Modal src-site R=    0.7 km; M= 6.85; eps0=   0.05 from peak (R,M) bin
Gridded source distance metrics: Rseis Rrup and Rjb
 MODE R*=   0.5km; M*= 6.85; EPS.INTERVAL: 0 to 1                      21.492

Principal sources (faults, subduction, random seismicity having >10%
contribution)
Source Category:                      % contr.   R(km)     M    epsilon0 (mean
values)
California SS faults                    93.65      2.1    6.78
Individual fault hazard details if contrib.>1%:
10 sh -- hs 2-1 10 mags                  2.54     12.0    6.69
9 sh+nh -- hs+hn 2-5 9mags               2.24     12.0    6.89    1.96
7 nc   -- cn--3-7 7mags                 60.89      0.7    6.81    0.06
7 cc+nc -- cc+cn-3-9 7mags               1.95      0.7    6.93    0.04
8 sc+cc+nc--cs+cc+cn-3-10 8mags         12.47      0.6    6.96    0.04
9 mtd-- 7-10 9mags                       6.56     11.5    6.65    1.54
floating sc+cc+nc                        6.45      1.5    6.17    0.52
```

Distance, R

Magnitude, M

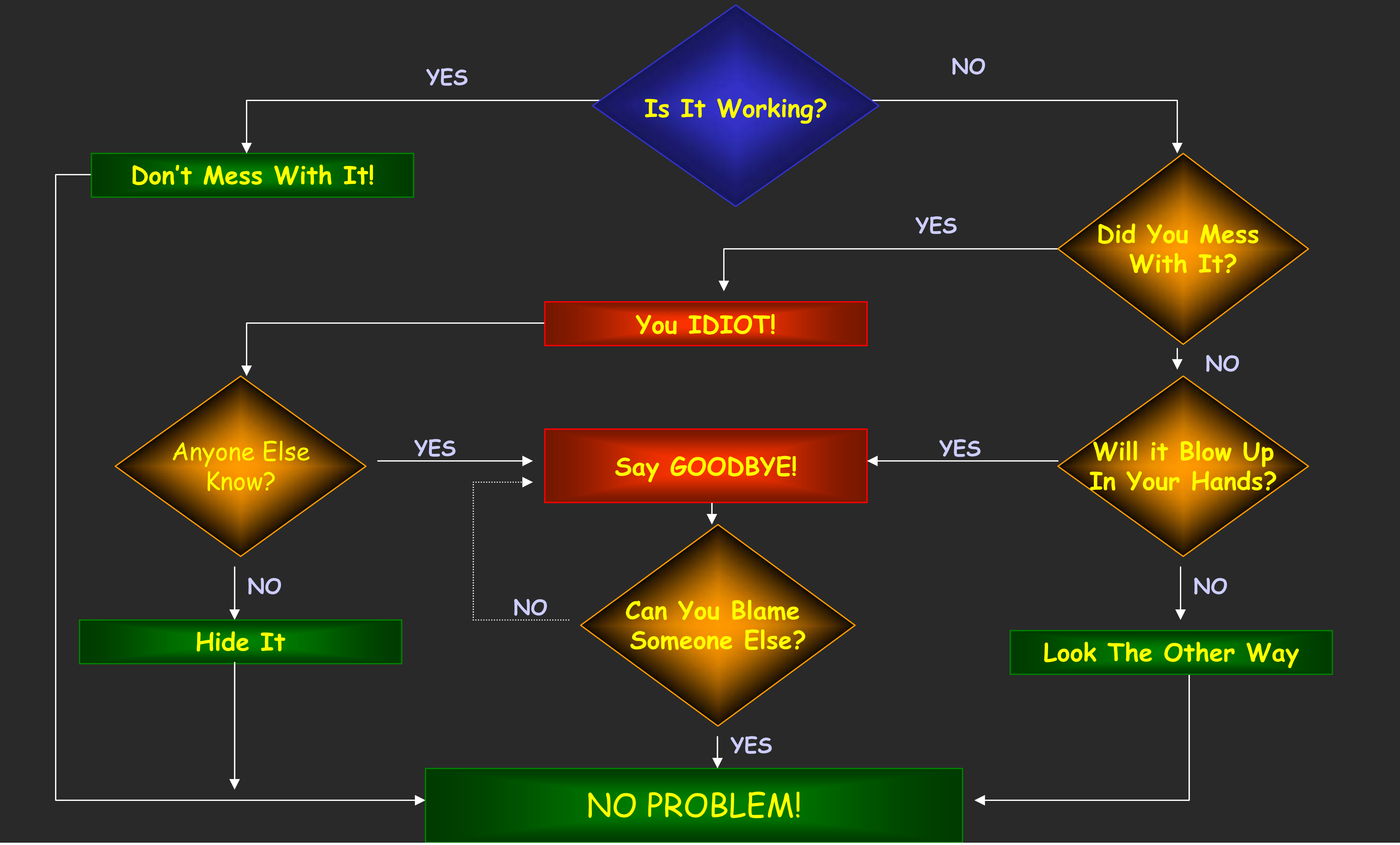
Ground Surface PGA

- Site response analysis
- Amplification factors (Stewart et al., 2003)

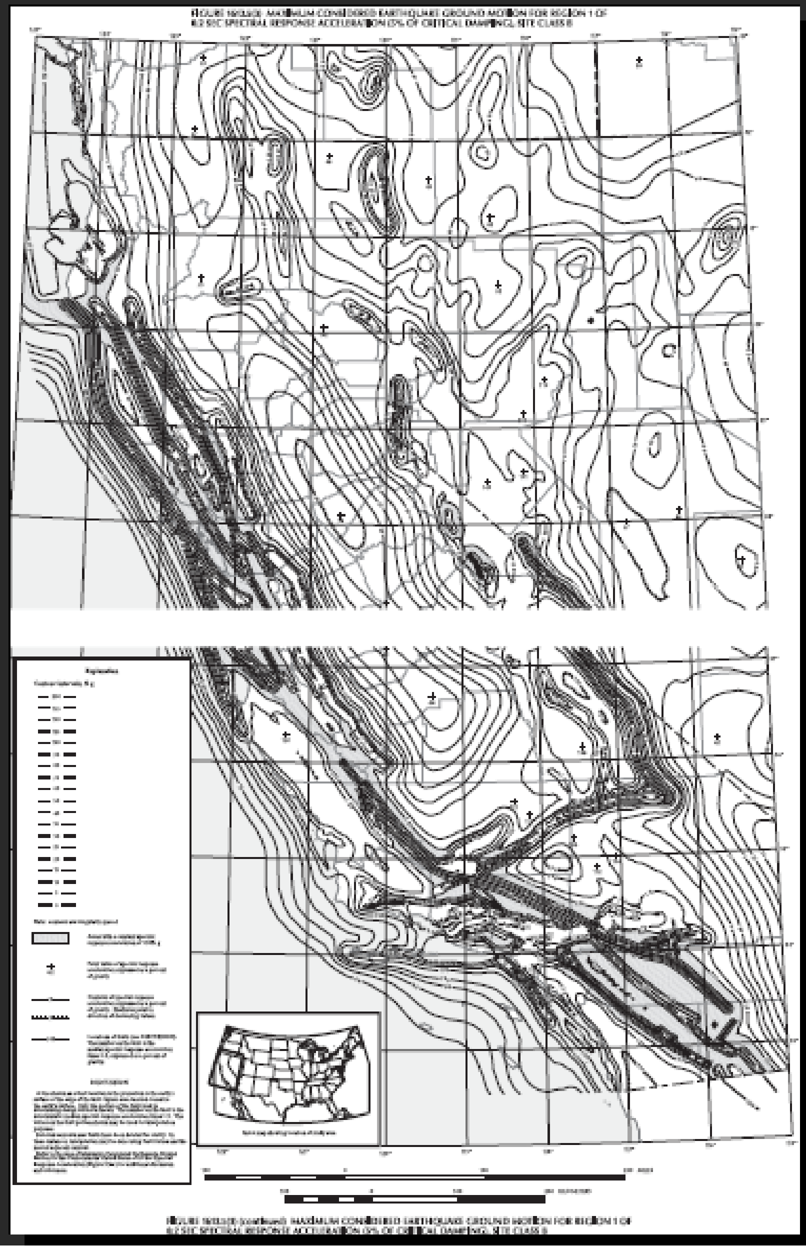
Future IBC (ASCE 7) Developments

- Updated MCE maps
- Basin effects
- Vertical design response spectrum
- Long-period transition period, T_L
- Soil-structure interaction (SSI) effects

Flowchart For Problem Resolution

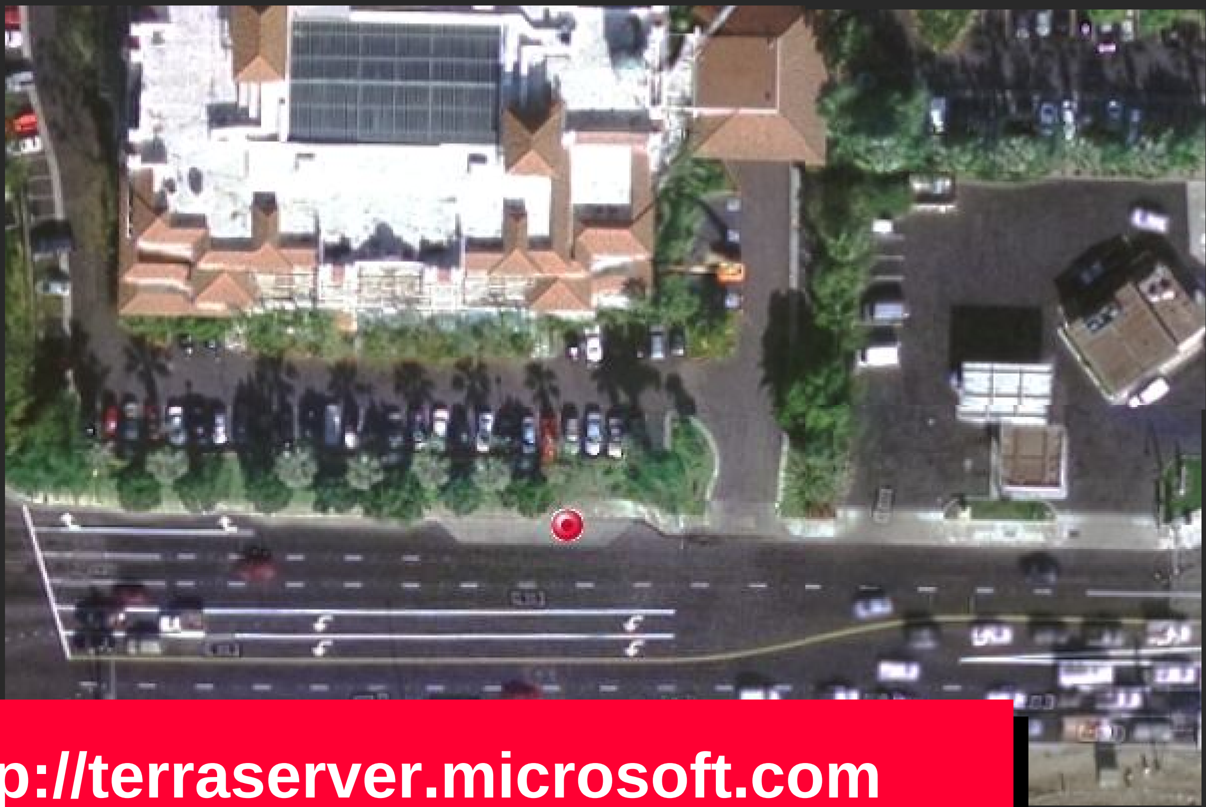


IBC Short Period Spectral Acceleration



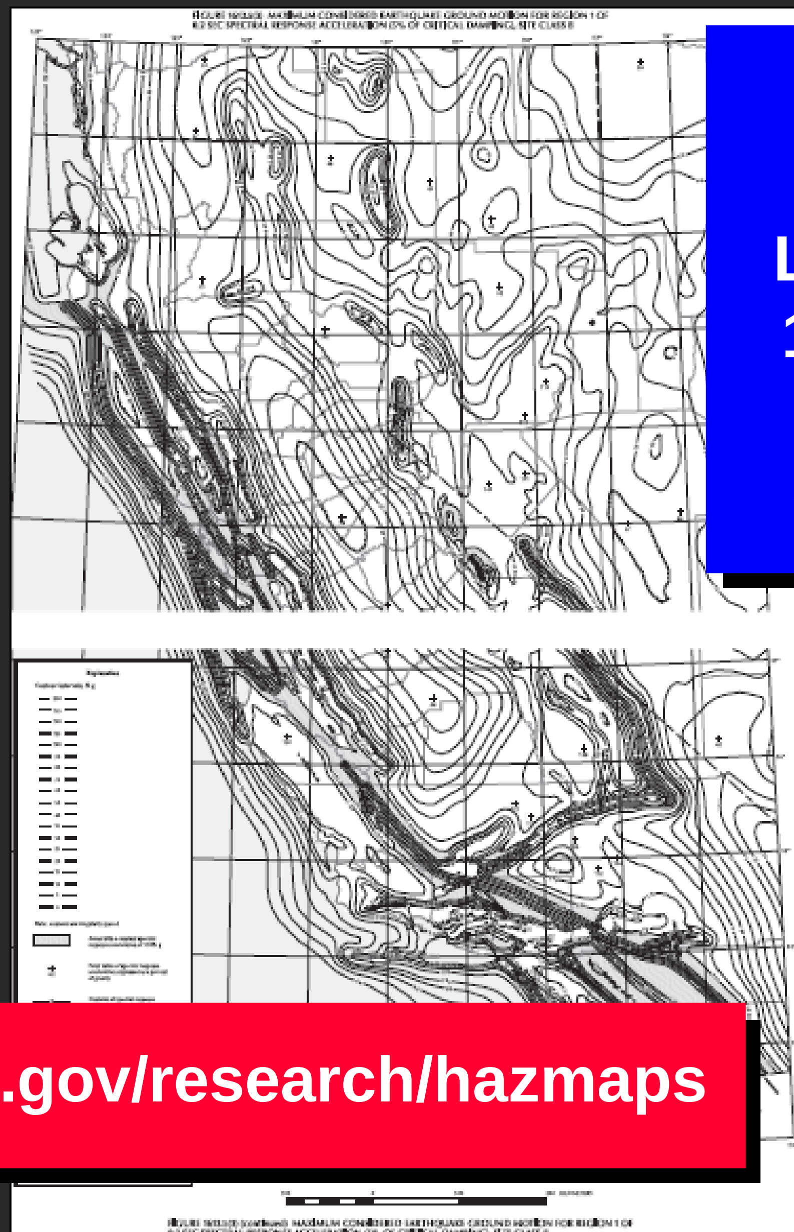
IBC Short Period Spectral Acceleration

1325 E. Dyer Road → 33.709N 117.853W



http://terraserver.microsoft.com

IBC Short Period Spectral Acceleration

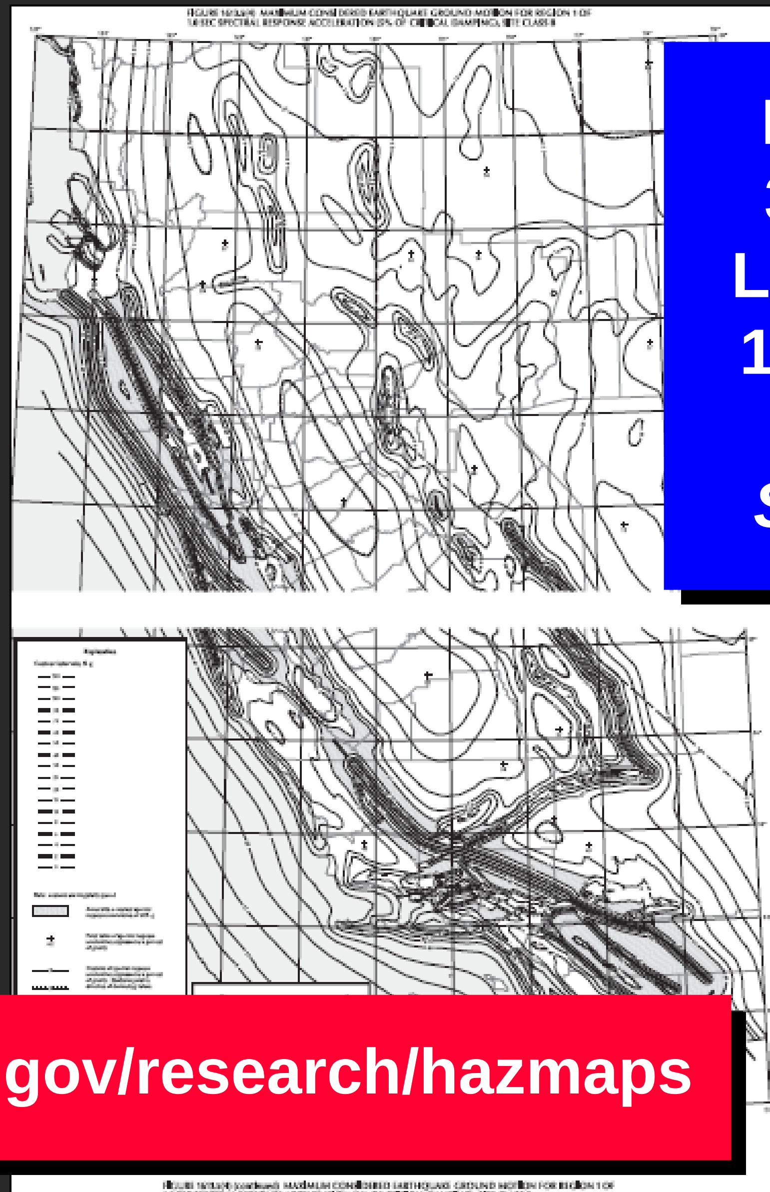


Latitude
33.709N
Longitude
117.853W

S_S = 1.50

http://earthquake.usgs.gov/research/hazmaps

IBC 1-Second Period Spectral Acceleration



Latitude
33.709N
Longitude
117.853W

$S_1 = 0.53$

http://earthquake.usgs.gov/research/hazmaps

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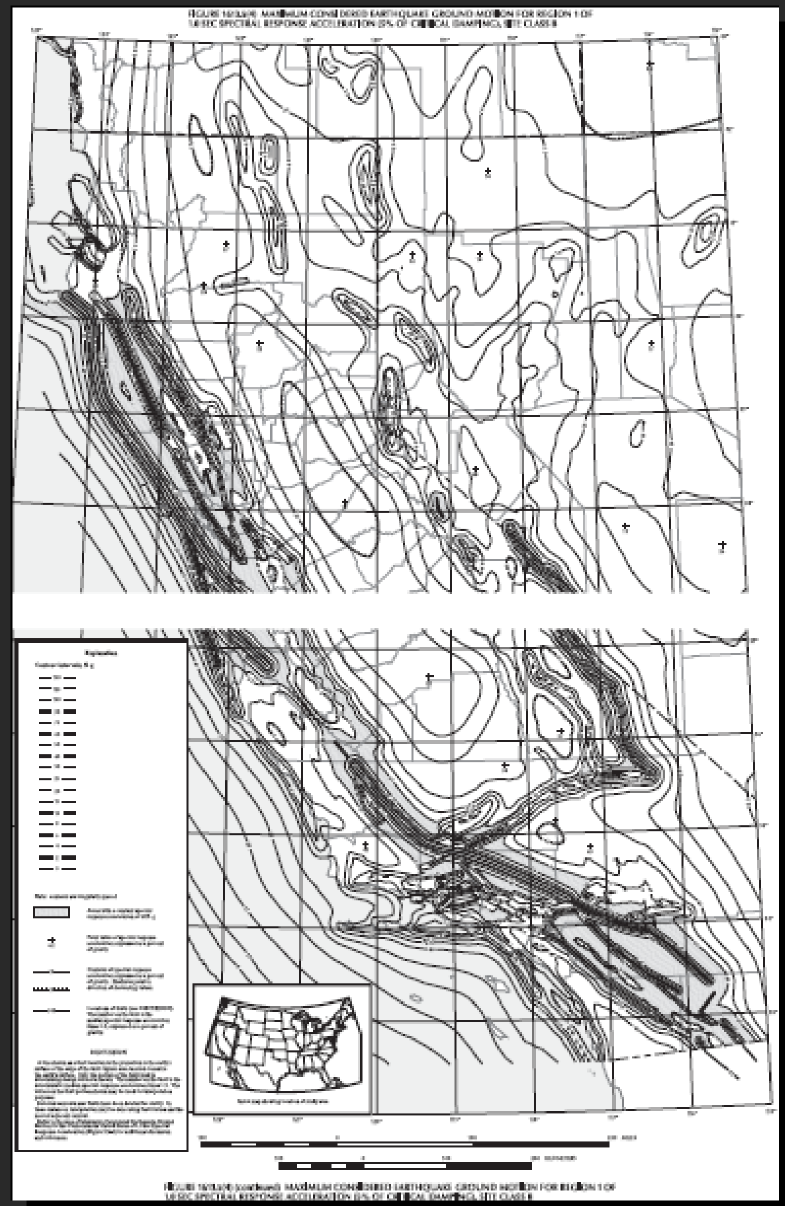
IBC 1-Second Period Spectral Acceleration



IBC Site Coefficients F_a and F_v

TABLE 1615.1.2(1)
VALUES OF SITE COEFFICIENT F_a AS A FUNCTION OF SITE CLASS AND MAPPED SPECTRAL RESPONSE ACCELERATION AT SHORT PERIODS (S_S)[a]

SITE CLASS	MAPPED SPECTRAL RESPONSE ACCELERATION AT SHORT PERIODS				
	$S_S \le 0.25$	$S_S = 0.50$	$S_S = 0.75$	$S_S = 1.00$	$S_S \ge 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	Note b	Note b	Note b	Note b	Note b

a. Use straight-line interpolation for intermediate values of mapped spectral response acceleration at short period, S_S.

b. Site-specific geotechnical investigation and dynamic site response analyses shall be performed to determine appropriate values, except that for structures with periods of vibration equal to or less than 0.5 second, values of F_a for liquefiable soils are permitted to be taken equal to the values for the site class determined without regard to liquefaction in Section 1615.1.5.1.

TABLE 1615.1.2(2)
VALUES OF SITE COEFFICIENT F_v AS A FUNCTION OF SITE CLASS AND MAPPED SPECTRAL RESPONSE ACCELERATION AT 1-SECOND PERIOD (S_1)[a]

SITE CLASS	MAPPED SPECTRAL RESPONSE ACCELERATION AT SHORT PERIODS				
	$S_1 \le 0.1$	$S_1 = 0.2$	$S_1 = 0.3$	$S_1 = 0.4$	$S_1 \ge 0.5$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	Note b	Note b	Note b	Note b	Note b

a. Use straight-line interpolation for intermediate values of mapped spectral response acceleration at 1-second period, S_1.

b. Site-specific geotechnical investigation and dynamic site response analyses shall be performed to determine appropriate values, except that for structures with periods of vibration equal to or less than 0.5 second, values of F_v for liquefiable soils are permitted to be taken equal to the values for the site class determined without regard to liquefaction in Section 1615.1.5.1.

Basic Needs Of The Structural Engineer

- Mapped acceleration parameters
  S_S = 1.50 and S_1 = 0.53
- Site class D
- Long-period transition period
  T_L = 8

Spectral Acceleration Parameters

Maximum Considered Earthquake (MCE)

$$S_{MS} = F_a * S_S$$
$$S_{M1} = F_v * S_1$$

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Spectral Acceleration Parameters

Maximum Considered Earthquake (MCE)

S_{MS} = 1.0 * 1.50 = 1.50
S_{M1} = 1.5 * 0.53 = 0.80

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Spectral Acceleration Parameters

Maximum Considered Earthquake (MCE)

$S_{MS} = 1.50$
$S_{M1} = 0.80$

→

Design Earthquake

$S_{DS} = 2/3 * S_{MS}$
$S_{D1} = 2/3 * S_{M1}$

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Spectral Acceleration Parameters

Maximum Considered Earthquake (MCE)

$S_{MS} = 1.50$
$S_{M1} = 0.80$

→

Design Earthquake

$S_{DS} = 2/3 * 1.50 = 1.00$
$S_{D1} = 2/3 * 0.80 = 0.53$

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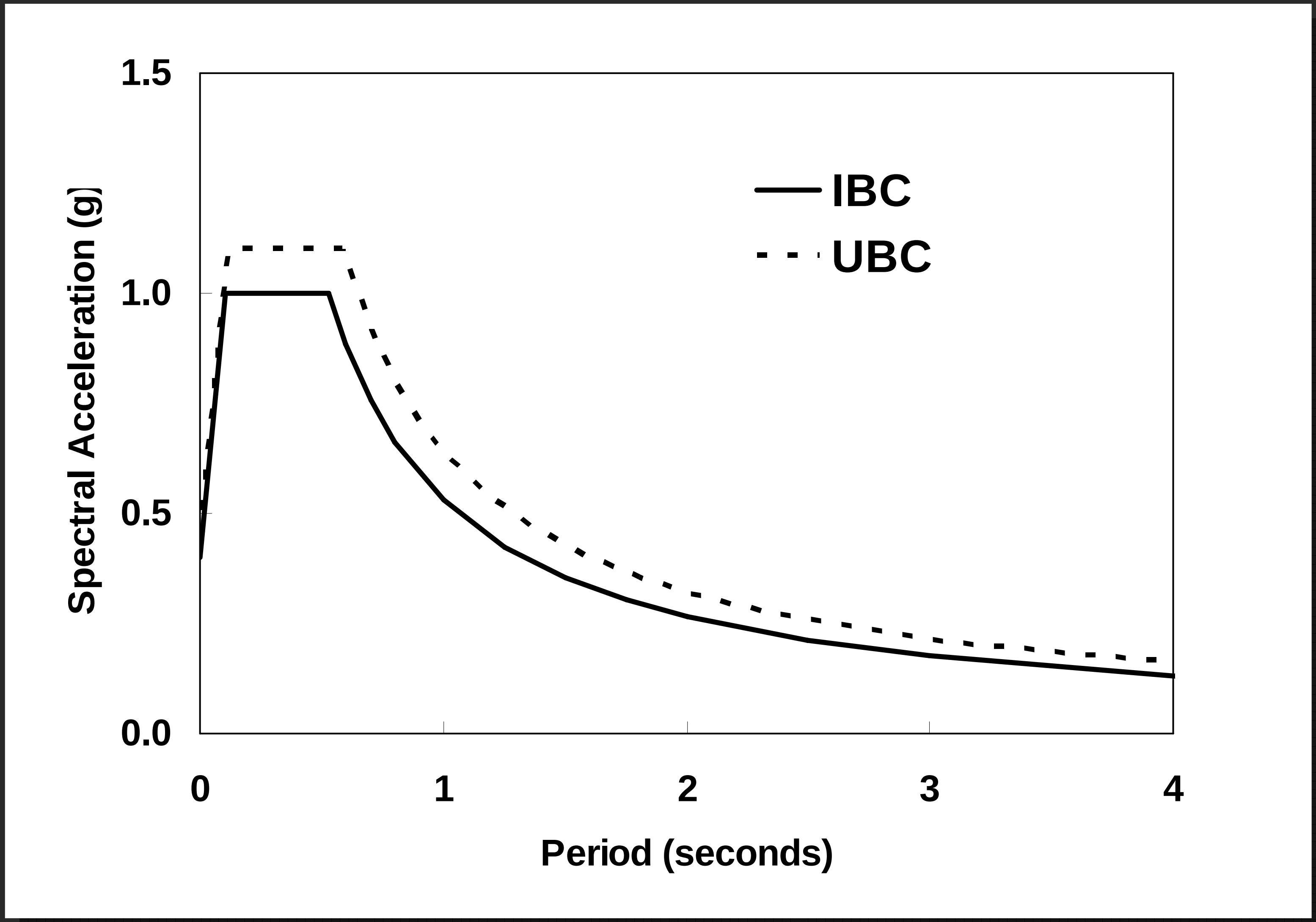
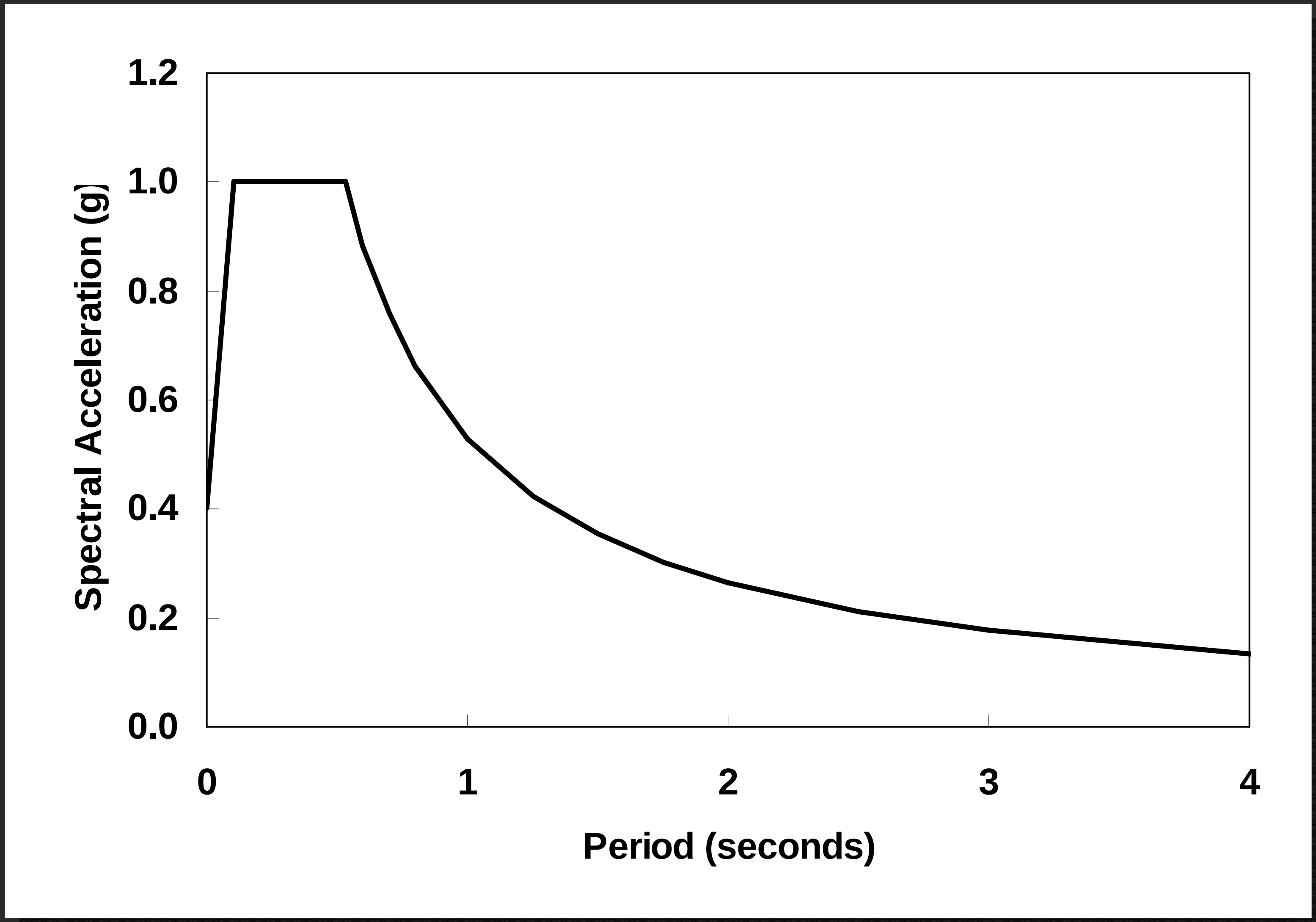
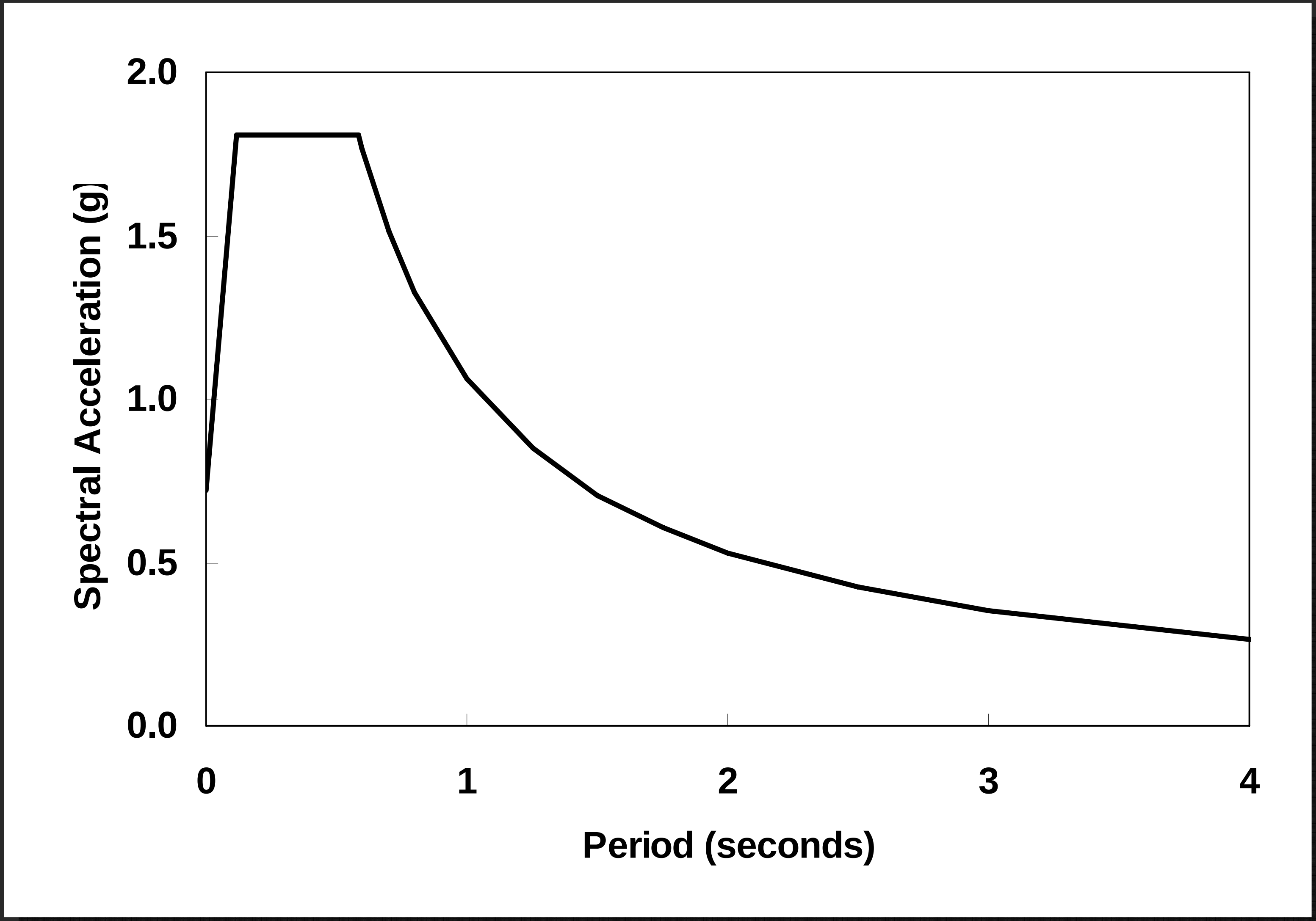
Design Response Spectrum



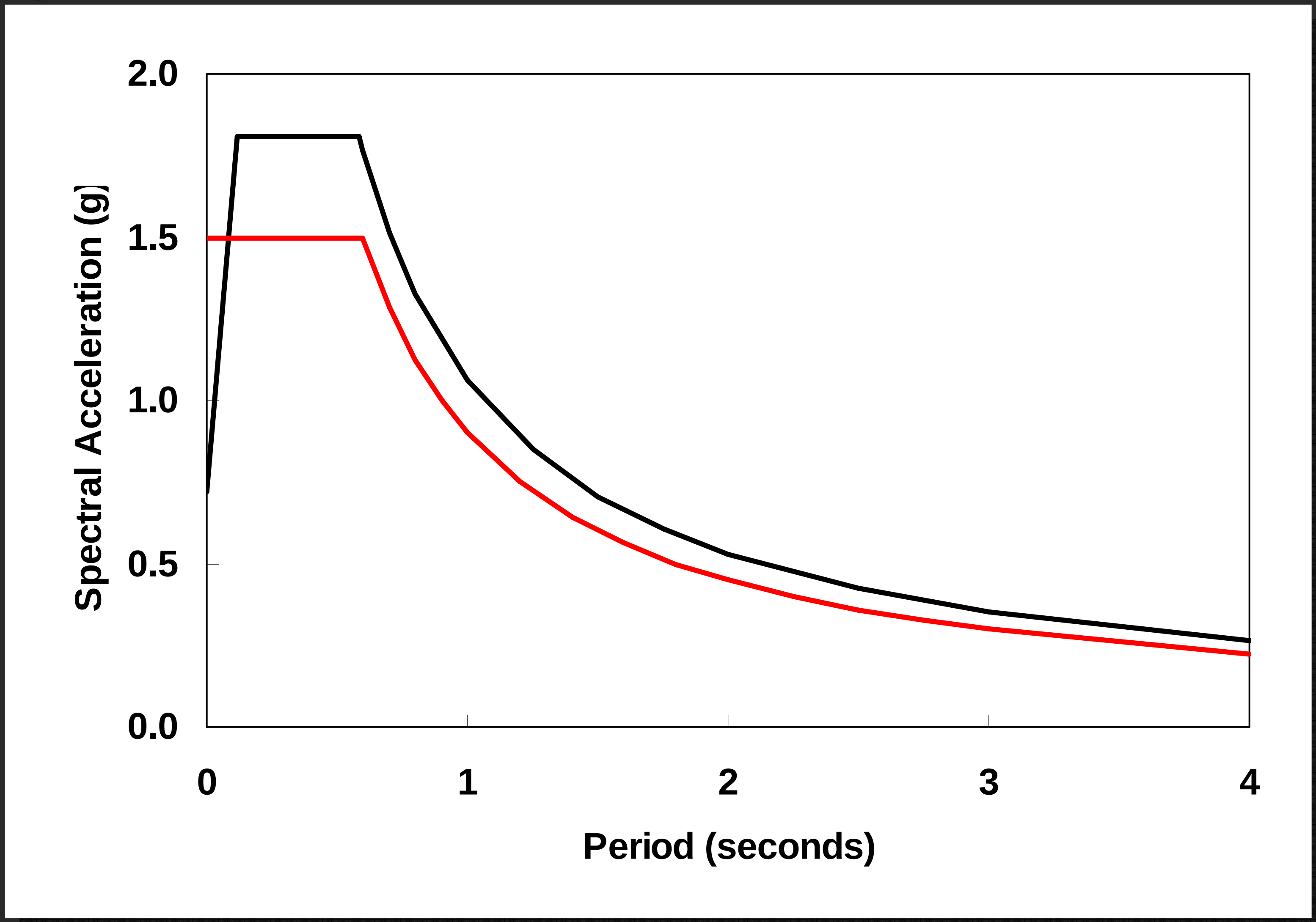
Design Response Spectrum



Design Spectrum



Design Spectrum



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Puerto Rico: latitude 17 to 19 degrees, longitude -64 to -68 degrees, only.
Latitude: 33.709 Longitude: -117.853

Return time:

PE = probability of exceedance
Select one!
- 1% PE in 50 years
- 2% PE in 50 years
- 5% PE in 50 years
- 10% PE in 50 yrs

SA frequency:

SA = Spectral Acceleration;
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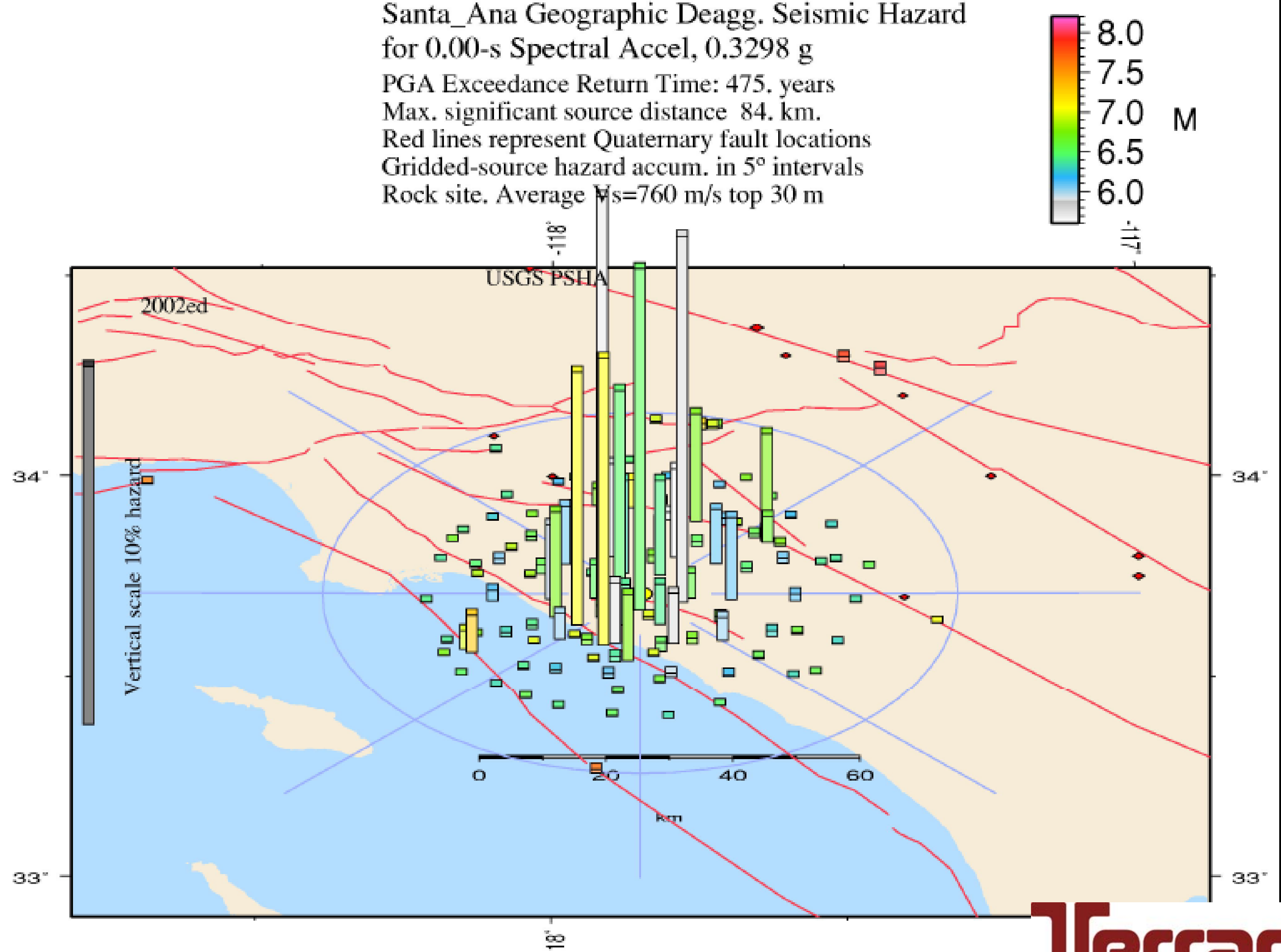
Puerto Rico: only 0.5 hz, 1.0 hz, 5.0 hz and PGA are available

Terracor

Santa_Ana Geographic Deagg. Seismic Hazard
for 0.00-s Spectral Accel, 0.3298 g
PGA Exceedance Return Time: 475. years
Max. significant source distance 84. km.
Red lines represent Quaternary fault locations
Gridded-source hazard accum. in 5° intervals
Rock site. Average Vs=760 m/s top 30 m



Terracon

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*** Data from U.S.G.S. National Seismic Hazards Mapping Project, 2002 version ***
PSHA Deaggregation. %contributions. site: Santa_Ana long: 117.853 W., lat: 33.709 N.
USGS 2002-03 update files and programs. dM=0.2. Site descr:ROCK
Return period: 2475 yrs. Exceedance PGA =0.6197 g.
#Pr[at least one eq with median motion>=PGA in 50 yrs]=0.00620

DIST(KM)	MAG(MW)	ALL_EPS	EPSILON>2	1<EPS<2	0<EPS<1	-1<EPS<0	-2<EPS<-1	EPS<-2
7.0	5.05	1.376	1.079	0.298	0.000	0.000	0.000	0.000
13.0	5.05	0.157	0.157	0.000	0.000	0.000	0.000	0.000
7.0	5.20	2.749	1.770	0.979	0.000	0.000	0.000	0.000
13.1	5.20	0.412	0.412	0.000	0.000	[illegible]	[illegible]	[illegible]
7.0	5.40	2.755	1.341	1.414	0.000	0.000	[illegible]	[illegible]
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13.5	5.60	0.695	0.695	0.000	0.000	0.000	[illegible]	[illegible]
7.0	5.80	2.725	0.740	1.961	0.025	0.000	[illegible]	[illegible]
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7.4	6.95	1.430	0.150	0.820	0.460	0.000	0.000	0.000
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23.8	7.01	0.090	0.090	0.000	0.000	0.000	0.000	0.000
13.0	7.21	1.905	0.817	1.088	0.000	0.000	0.000	0.000
13.3	7.42	0.126	0.049	0.077	0.000	0.000	0.000	0.000

10% in 50 year

PGA = 0.33g

Summary statistics for above PSHA PGA deaggregation, R=distance, e=epsilon:
Mean src-site R= 6.5 km; M= 6.38; eps0= 0.67. Mean calculated for all sources.
Modal src-site R= 4.0 km; M= 6.44; eps0= 0.01 from peak (R,M) bin
Gridded source distance metrics: Rseis Rrup and Rjb
MODE R*= 3.9km; M*= 6.45; EPS.INTERVAL: 0 to 1 sigma % CONTRIB.= 13.929

Principal sources (faults, subduction, random seismicity having >10% contribution)

Source Category:	% contr.	R(km)	M	epsilon0 (mean values)
Calif. thrust/reverse faults	45.34	3.6	6.54	-0.14
California shallow gridded	45.14	8.0	6.10	1.26

Individual fault hazard details if contrib.>1%:

2	Newport-Inglewood offshore	3.43	14.3	7.02	1.90
2	Newport-Inglewood	4.25	12.4	7.02	1.63
2	Newport-Inglewood GR M-distri	1.32	13.1	6.79	1.80
2	San Joaquin Hills Thrust	28.65	3.5	6.56	-0.16
2	San Joaquin Hills Thrust GR M	16.53	3.5	6.51	-0.14

Summary statistics for above PSHA PGA deaggregation, R=distance, e=epsilon:

Mean src-site R= 12.2 km; M= 6.35; eps0= 0.45. Mean calculated for all sources.

Modal src-site R= 4.4 km; M= 6.43; eps0= -0.99 from peak (R,M) bin

Gridded source distance metrics: Rseis Rrup and Rjb …

MODE R*= 4.4km; M*= 6.43; EPS.INTERVAL: 0 to 1 s… 5.387

Distance, R

Magnitude, M

Principal sources (faults, subduction, random seismicity having >10% contribution)

Source Category:	% contr.	R(km)	M	epsilon0 (mean values)
Calif. thrust/reverse faults	16.62	5.3	6.56	-1.10
California shallow gridded	54.02	10.8	5.97	
Calif b, SS or Thrust	23.14	16.4	6.96	
Individual fault hazard details if contrib.>1%:				
2 Newport-Inglewood offshore	8.07	14.4	7.01	0.51
2 Newport-Inglewood	7.12	12.4	7.01	0.25
2 Newport-Inglewood offshore GR	1.87	17.7	6.80	1.06
2 Newport-Inglewood GR M-distri	2.96	14.4	6.78	0.66
2 San Joaquin Hills Thrust	9.66	3.5	6.55	-1.32
2 San Joaquin Hills Thrust GR M	5.67	3.6	6.50	-1.27
2 Palos Verdes	1.05	30.6	7.27	1.94
Elsinore-16	2.94	25.7	6.79	1.93
Elsinore-15	2.91	22.6	6.78	1.66