မြန်မာနိုင်ငံအင်ဂျင်နီယာအသင်းချုပ်

FEDERATION OF MYANMAR ENGINEERING SOCIETIES
(Fed.MES)

MNBC 2020, Part 3

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FEDERATION OF MYANMAR ENGINEERING SOCIETIES

9 December 2023

Yangon, Myanmar

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- MNBC Structural Design follows IBC-2006 and ASCE7-05 codes.
- MNBC started in 2010 and referred International Codes of 2005-06.
- MNBC tried to combine two codes (IBC and ASCE7) in order to compile them into one volume.
- The construction environment in Myanmar has been changed significantly since 2010.
  - PE system enacted together with Engineering Council Law.
  - Construction quality awareness has raised.

MYANMAR NATIONAL BUILDING CODE - 2012

PART 3 STRUCTURAL DESIGN

MNBC basic concepts

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Design

Supply = Demand

Capacity = Demand

Reaction = Action

Strength = Load

Something just right.

Particular solution.

Design

For

General Solution,

Supply > Demand

Capacity > Demand

Reaction > Action

Strength > Load

Something is always more than required.

Design

Rewriting them as,

Supply = FOS x Demand

Capacity = FOS x Demand

Reaction = FOS x Action

Strength = FOS x Load

How much FOS (Factor of Safety) is needed?

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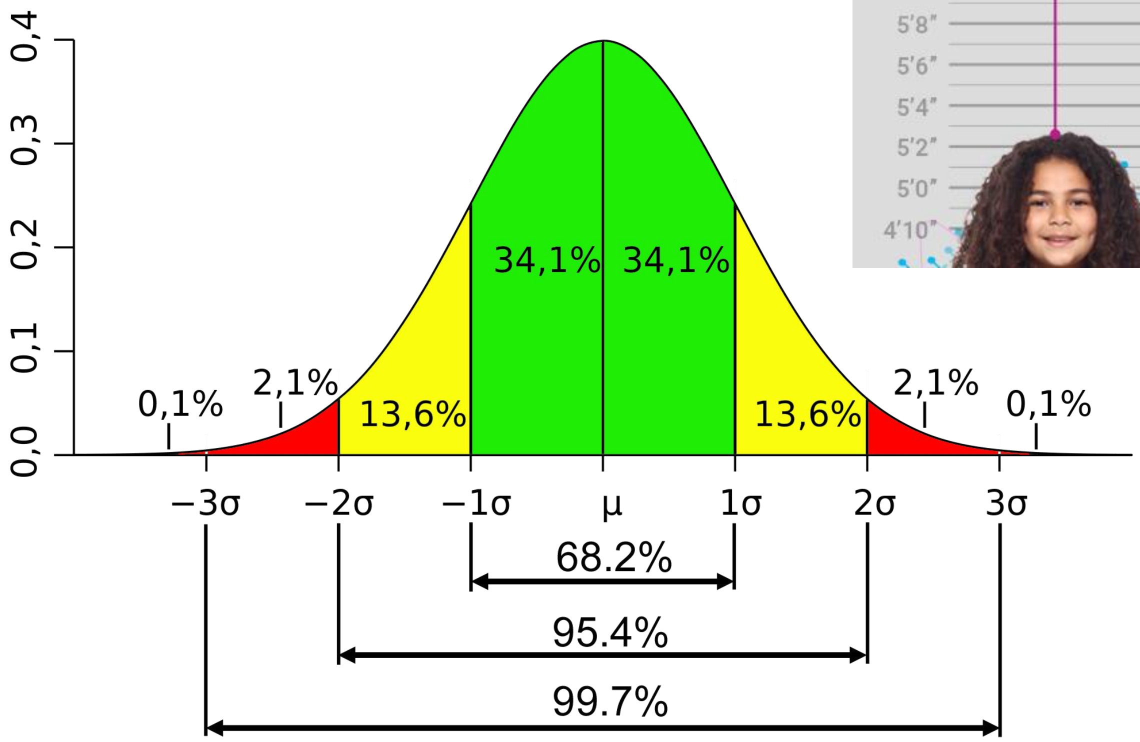
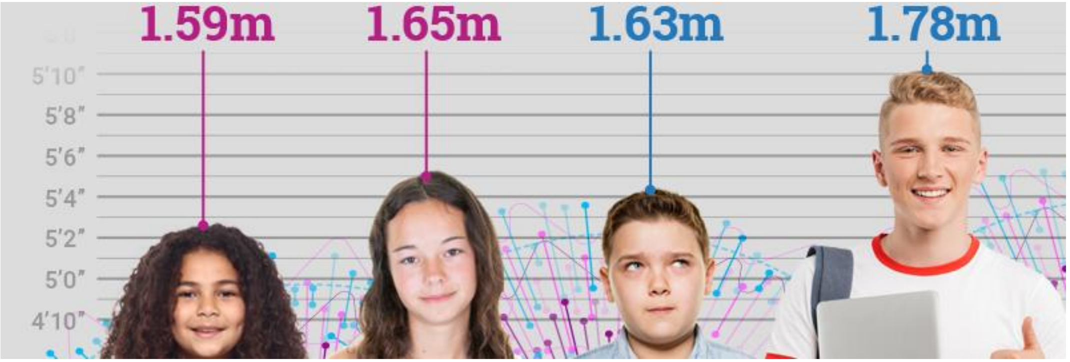
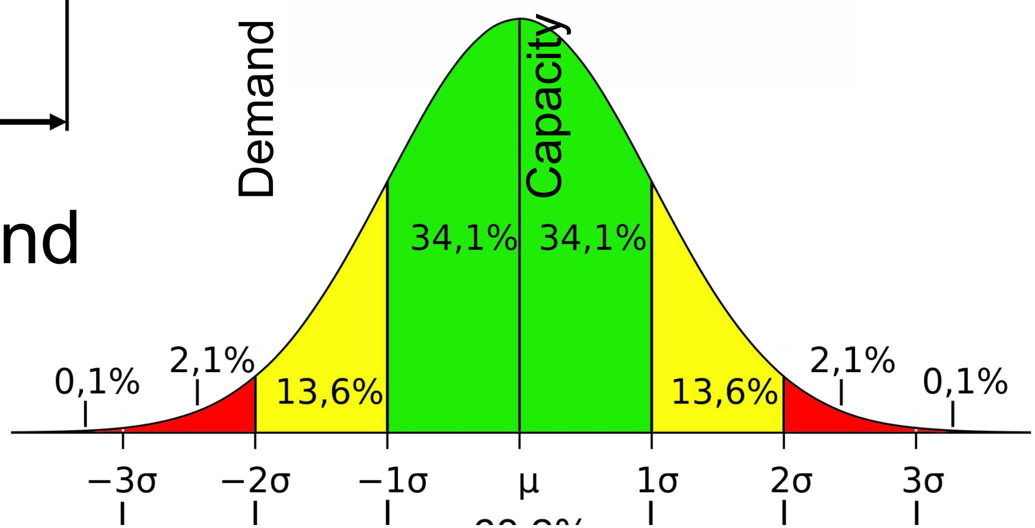
Factor of Safety





$$s = \sqrt{\frac{\sum (x - \bar{x})^2}{n - 1}}$$

- Capacity = FOS x Demand



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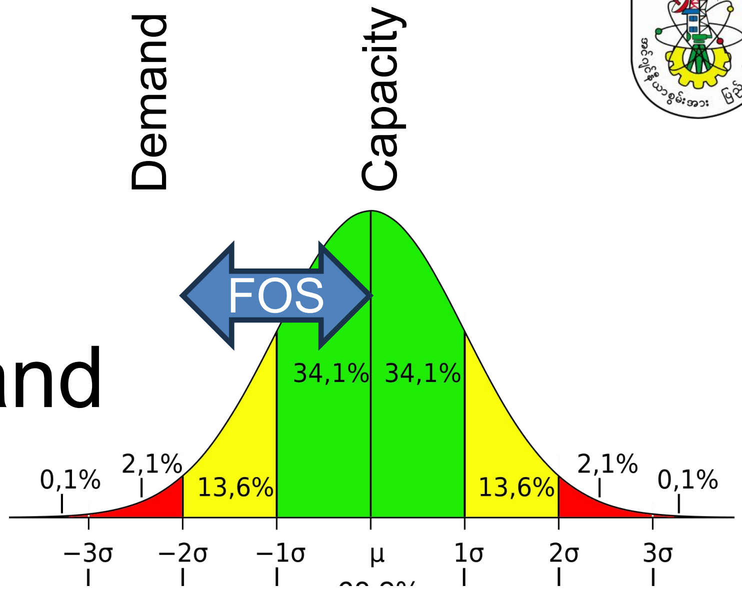
ASD vs LRFD

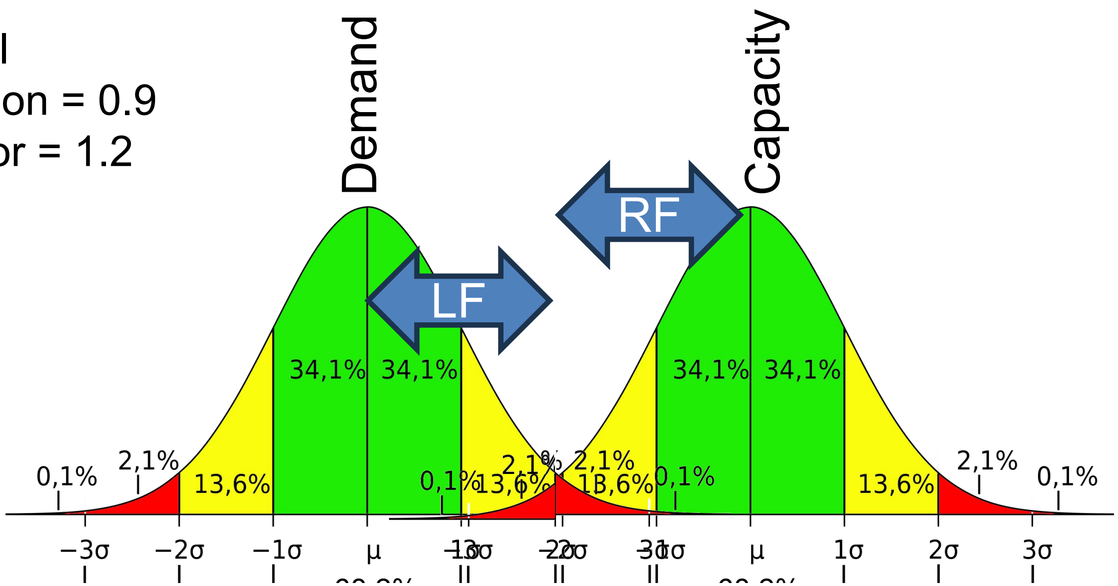
- ASD:
- Capacity / FOS = Demand

Soil Spring / 3 = Bearing Capacity



- LRFD:
- Capacity / Reduction = Demand x Load Factor

Reinforcing Steel
Strength Reduction = 0.9
Dead Load Factor = 1.2



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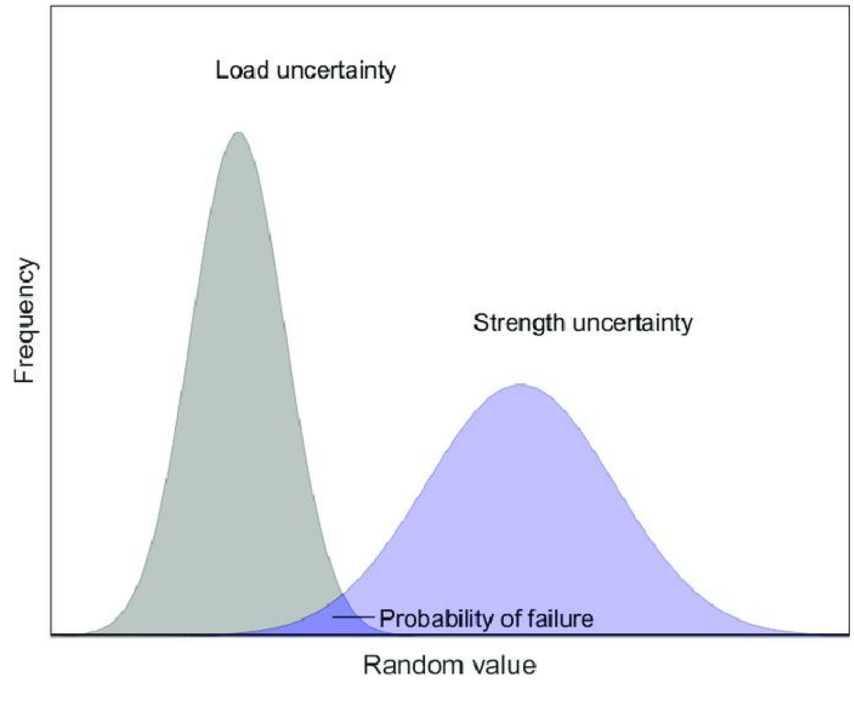
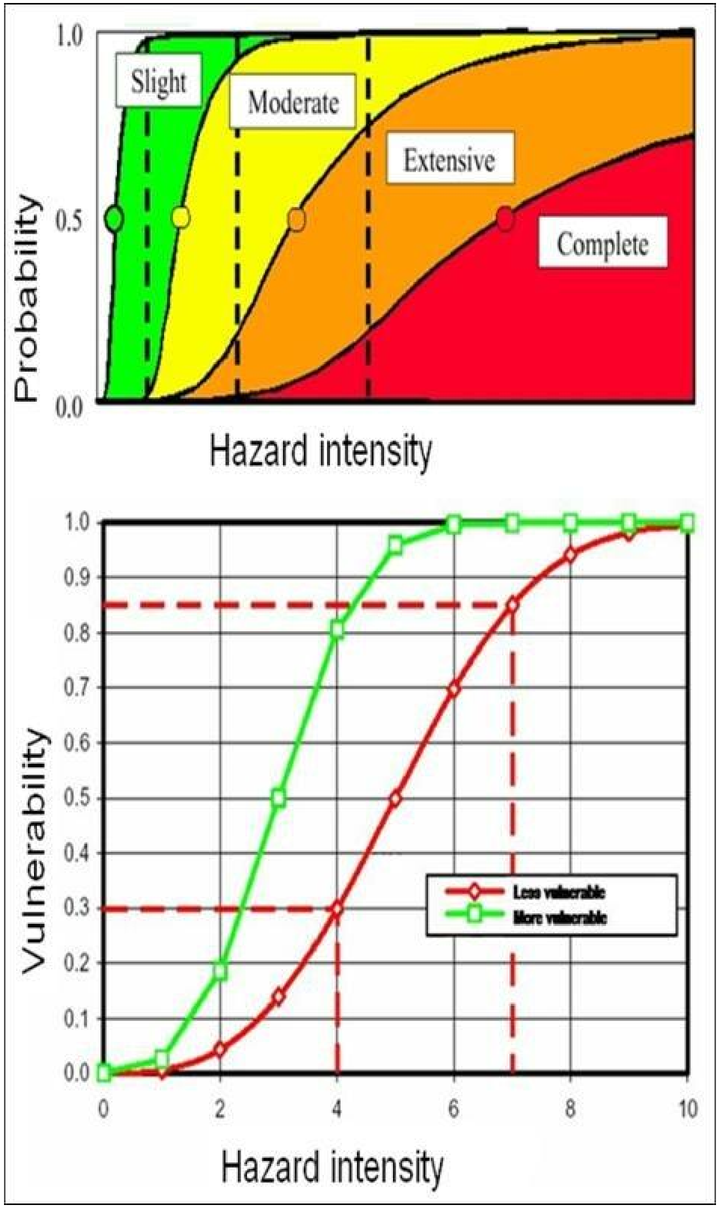
s of human lives which is not acceptable.





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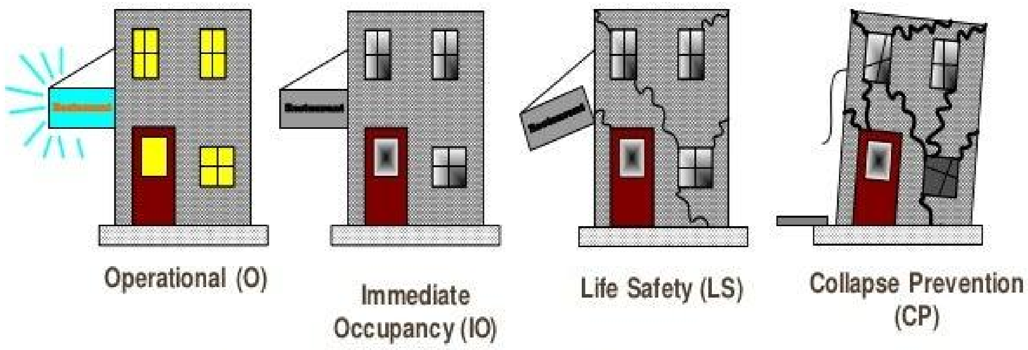
Disaster Events



- **Normal Buildings**
  - Life Safety in Big Event
    (rare event, MCE, BSE-2N, 2% in 50 years)
  - Minor Damage in Small Event
    (frequent event, DBE, BSE-1N, 10%in 50 years)
- **Important Buildings**
  - Operational in Big Event
    (rare event, MCE, 2% in 50 years)
  - No Damage in Small Event
    (frequent event, DBE, 10%in 50 years)

HAZARD RISK ASSESSMENT MATRIX

	Hazard Categories			
Frequency of Occurrence	1 Catastrophic	2 Critical	3 Serious	4 Minor
(A) Frequent	1A	2A	3A	4A
(B) Probable	1B	2B	3B	4B
(C) Occasional	1C	2C	3C	4C
(D) Remote	1D	2D	3D	4D
(E) Improbable	1E	2E	3E	4E

Unacceptable (red): 1A, 2A, 3A, 1B, 2B, 1C
High (yellow): 3B, 2C, 3C, 1D, 2D
Medium (orange): 4A, 4B
Low (blue): 4C, 3D, 4D, 1E, 2E, 3E, 4E

Unacceptable High Medium Low

For new buildings,

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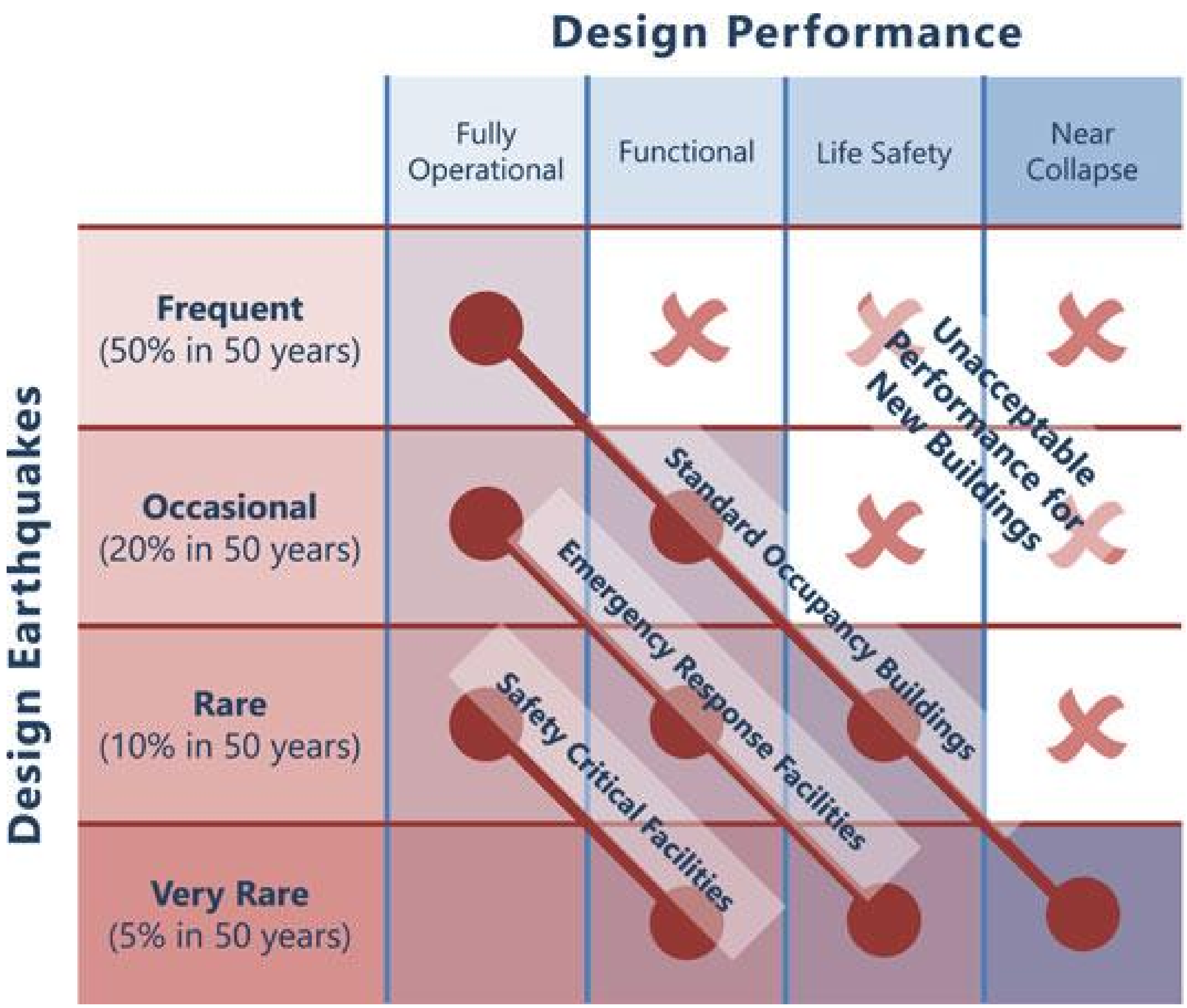
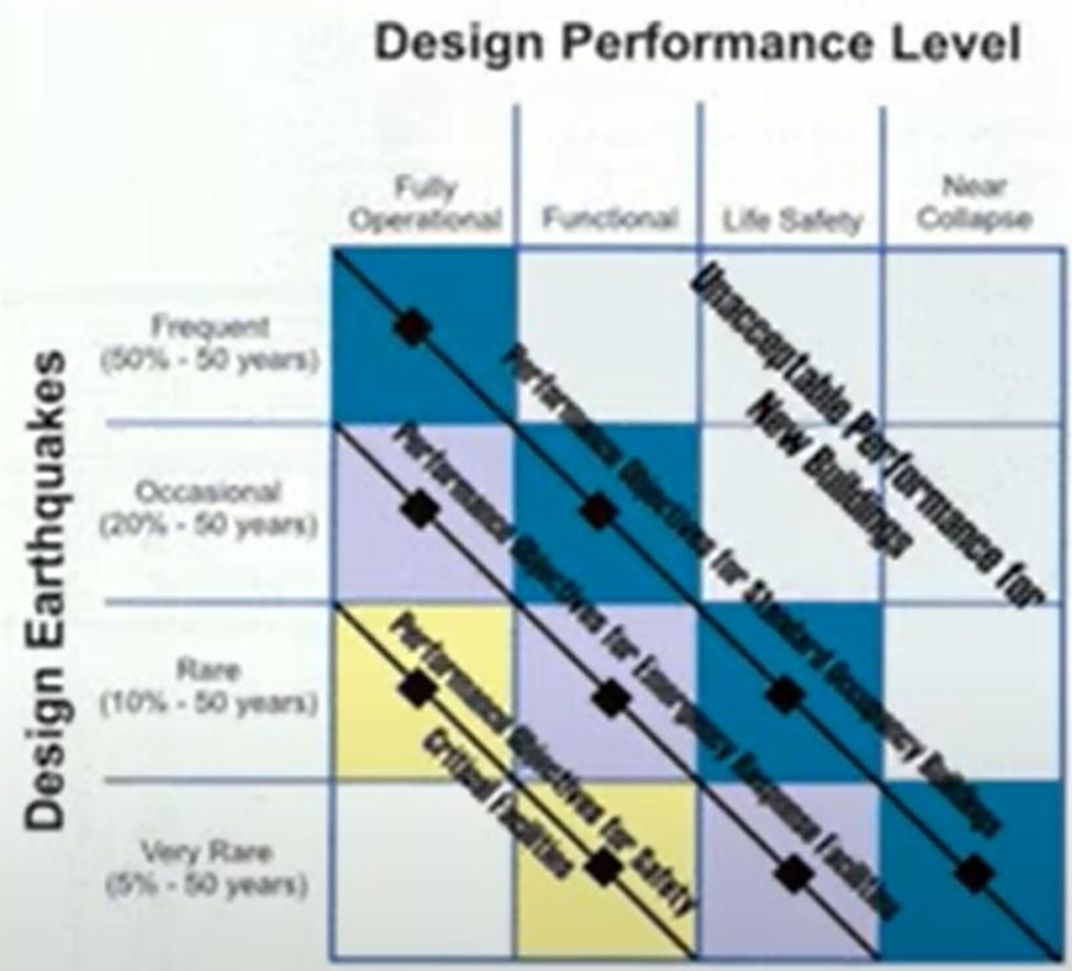


For existing buildings,

- **Life Safety in the 10%/50y Event**
- **Near Collapse in the 10%/100y Event (a.k.a. 5%/50y Event)**



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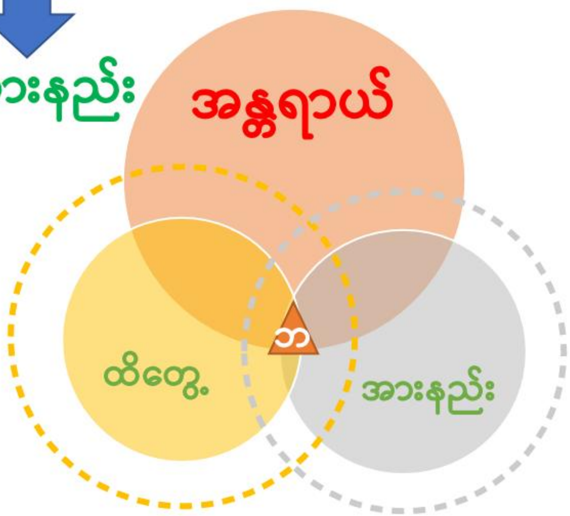
ဘေးဖြစ်နိုင်ခြေ လျှော့ချခြင်း

အားနည်းမှုလျှော့ချ

- အသိပညာတိုးစေ
- တုန့်ပြန်နိုင်စွမ်းတိုးစေ

ဘေးဖြစ်နိုင်ခြေ = အန္တရာယ် x ထိတွေ့ x အားနည်း



ထိတွေ့မှုလျှော့ချ

- မြို့ရွာဖွံ့ဖြိုးမှု စံနစ်ကျစေ
- ထိခိုက်နိုင်ခြေမြင့်သော နေရာများကိုရှောင်ရှား

Risk = Hazard x Exposure x Vulnerability

$$Risk = Hazard * Exposure * Vulnerability$$

$$Risk = Hazard * Vulnerability$$

$$Vulnerability = \frac{1}{Strength}$$

$$Risk = \frac{Hazard}{Strength}$$

$$Risk = \frac{Demand}{Capacity} = DemandCapacityRatio$$

$$Safety = \frac{Strength}{Hazard}$$

$$Safety = \frac{Strength}{Hazard}$$ → Performance Based Design

$$Safety = \frac{Strength}{Hazard}$$ → Code Based Design

MNBC 2020, Part 3, Structural Design Scope

$$Safety = \frac{Strength}{Hazard}$$

→ Code Based Design

Hazard, Load, Safety:

- MNBC 2020

- Strength, Capacity, Member Design:
  - Concrete: ACI
  - Steel: AISC
  - Masonry: Not Yet
  - Timber and Bamboo: Not Yet
  - Cold-form, Aluminum: Not Yet

$$Safety = \frac{Capacity}{Load}$$

$$Risk = \frac{Load}{Capacity}$$

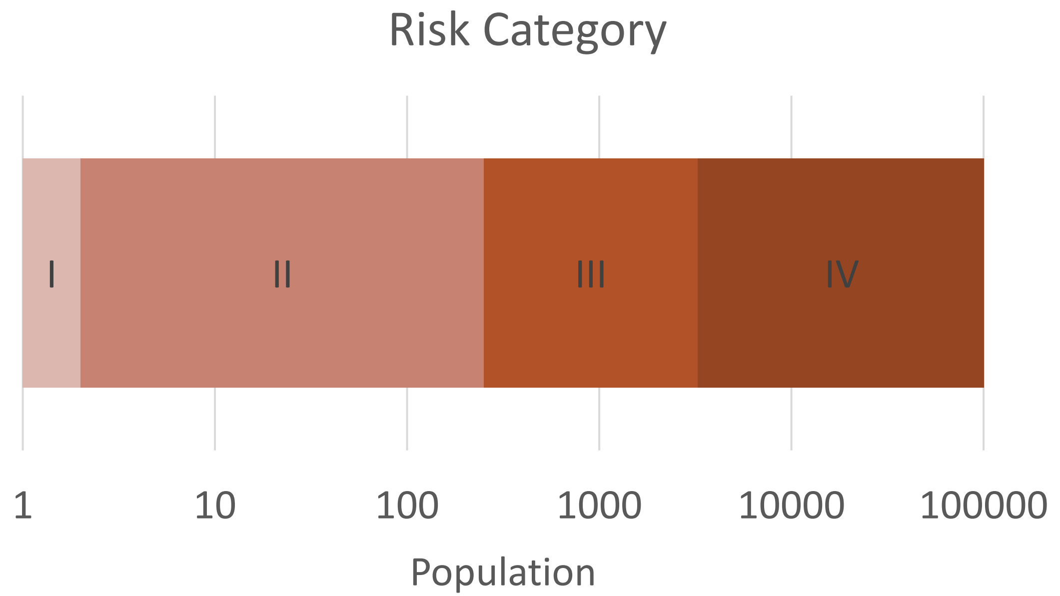
Risk and Safety

- RISK, SAFETY, LOAD AND CAPACITY

Occupancy Category (will be used as "Risk Category" after ASCE7-10 and later)

Buildings shall be designed according to their "Risk" category

Risk Category	Nature of Occupancy
I	Representing a low hazard to human life in the event of failure
II	Except those listed in other categories
III	Represent a substantial hazard to human life in the event of failure
IV	Designed as essential facilities



Risk Category defined in recent ASCE7-16

Category	Occupancy	NATURE OF OCCUPANCY
I	Low	Use or Occupancy of Buildings and Structures Risk Category Buildings and other structures that represent a low risk to human life in the event of failure.
II	Medium	All buildings and other structures except those listed in Risk Categories I, III, and IV.
III	High	Buildings and other structures, the failure of which could pose a substantial risk to human life. Buildings and other structures, not included in Risk Category IV, with potential to cause a substantial economic impact and/or mass disruption of day-to-day civilian life in the event of failure. Buildings and other structures not included in Risk Category IV (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, hazardous waste, or explosives) containing toxic or explosive substances where their quantity exceeds a threshold quantity established by the Authority Having Jurisdiction and is sufficient to pose a threat to the public if released.
IV	Essential	Buildings and other structures designated as essential facilities. Buildings and other structures, the failure of which could pose a substantial hazard to the community. Buildings and other structures (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, or hazardous waste) containing sufficient quantities of highly toxic substances where the quantity exceeds a threshold quantity established by the authority having jurisdiction to be dangerous to the public if released and is sufficient to pose a threat to the public if released. Buildings and other structures required to maintain the functionality of other Risk Category IV structures.

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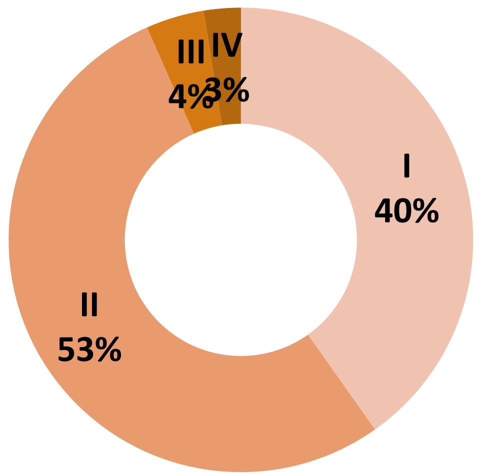
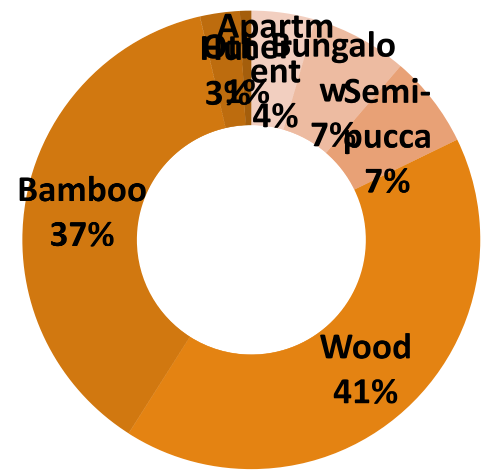
Risk Category (Union)



Building Type (Union)



Category	Risk Category	Apartment	Bungalow	Semi-pucca	Wood	Bamboo	Hut	Other	All Buildings
I	Temporary					37.40%	2.80%		40.20%
II	Medium		6.12%	5.85%	41.20%				53.17%
III	High	4.05%							4.05%
IV	Ess/Haz	0.45%	0.68%	0.65%				0.80%	2.58%
	Union	4.50%	6.80%	6.50%	41.20%	37.40%	2.80%	0.80%	100.00%

Occupancy Category (will be used as "Risk Category" after ASCE7-10 and later)

Buildings shall be designed according to their "Risk" category

Looks similar to Engineering Council Rule PE / RSE work scope

104. The registered senior engineer have the right to operate the following engineering works constrained by these rules, by calculation of design, signing the layout and construction without the supervision of the registered professional engineer.

(a) **Civil Engineering Works**

(i) Normal residential building, not public buildings (such as school, hospital, cinema hall, sport ground, city hall and supermarket and the others) not extensive than flooring area 1000sq m and not higher than 28 meters until floral accents;

(ii) Two-lane tar and concrete roads under the capacity load 13 tons;

(iii) House posts distance under 20 meters and steel and iron concrete bridges under the capacity load 40 tons;

(iv) Earthen reservoirs under 30 meters high.

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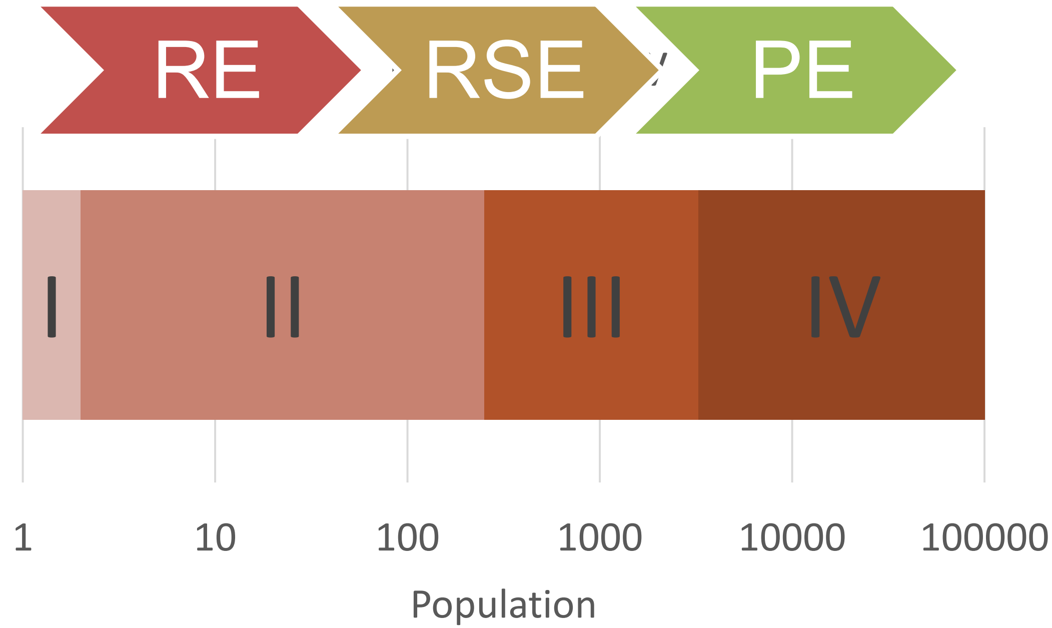
Risk Category	Nature of Occupancy
I	Representing a low hazard to human life in the event of failure
II	Except those listed in other categories
III	Represent a substantial hazard to human life in the event of failure
IV	Designed as essential facilities



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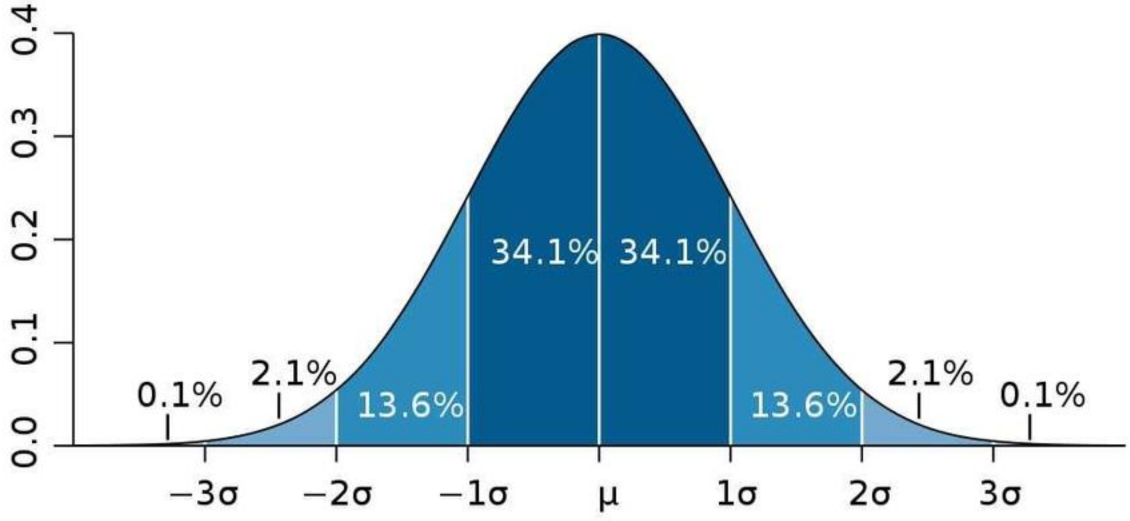
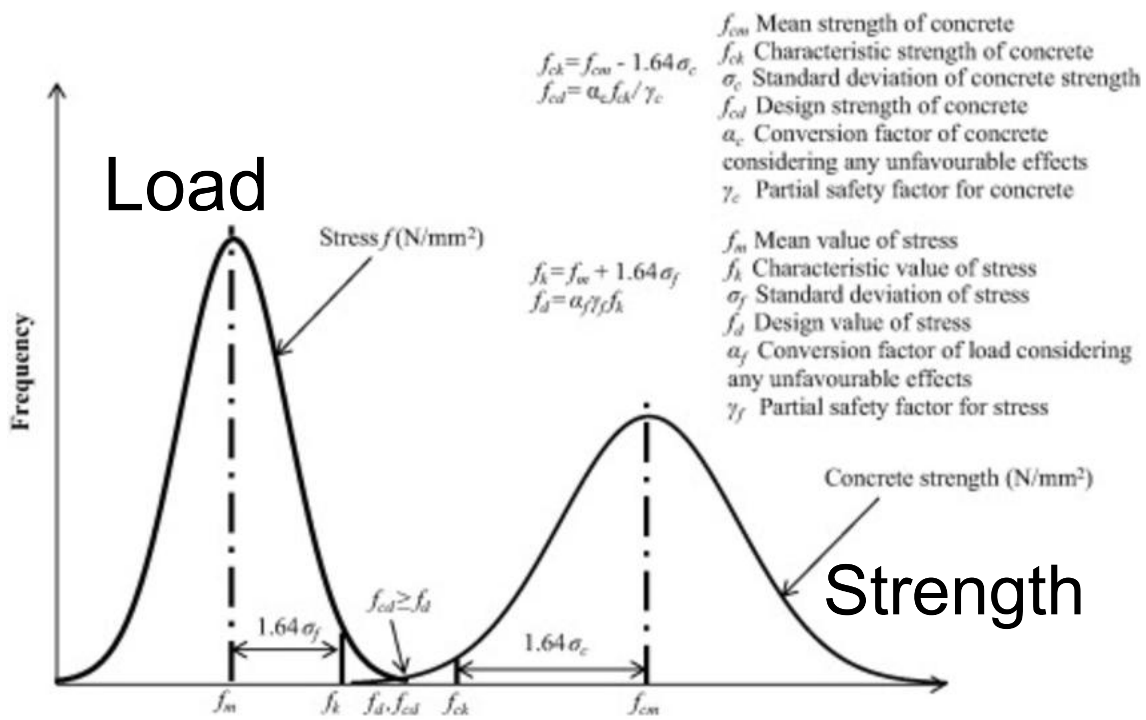




Loads

Combining Factored Loads Using Strength Design or Load and Resistance Factor Design

3.2.1.2.2 Basic load combinations

Structures, components, and foundations shall be designed so that their design strength equals or exceeds the most critical effects of the factored loads in the following combinations:

1. $1.4\ (D + F)$ Eq. (3.2.1)
2. $1.2(D+F+T) + 1.6(L+H) + 0.5\ (L_r \text{ or } R)$ Eq. (3.2.2)
3. $1.2D + 1.6(L_r \text{ or } R) + (L \text{ or } 0.8W)$ Eq. (3.2.3)
4. $1.2D + 1.6W + L + 0.5(L_r \text{ or } R)$ Eq. (3.2.4)
5. $1.2D + 1.0E + L$ Eq. (3.2.5)
6. $0.9D + 1.6W + 1.6H$ Eq. (3.2.6)
7. $0.9D + 1.0E + 1.6H$ Eq. (3.2.7)

Combining Nominal Loads Using Allowable Stress Design or Working Stress Design

3.2.1.3.1 Basic load combinations

Loads listed herein shall be considered to act in the following combinations; whichever produces the most unfavorable effect in the building, foundation, or structural member being considered. Effects of one or more loads not acting shall be considered.

1. $D + F$ Eq. (3.2.8)
2. $D + H + F + L + T$ Eq. (3.2.9)
3. $D + H + F + (L_r \text{ or } R)$ Eq. (3.2.10)
4. $D + H + F + 0.75(L + T) + 0.75\ (L_r \text{ or } R)$ Eq. (3.2.11)
5. $D + H + F + (W \text{ or } 0.7E)$ Eq. (3.2.12)
6. $D + H + F + 0.75(W \text{ or } 0.7E) + 0.75L + 0.75\ (L_r \text{ or } R)$ Eq. (3.2.13)
7. $0.6D + W + H$ Eq. (3.2.14)

Wind Load

Wind Load Characterization

Wind Design Flow Chart- Method 1: Simplified Procedure

ASCE 7-05 Wind Pressures

- The basic form of the pressure equation:

  - $p = qGC$

- Where
  - p = a wind pressure on a surface
  - q = velocity pressure. This is the pressure due to a moving fluid on a flat plate
  - G = gust factor. The gust factor accounts for dynamic interaction between the flowing air and the structure
  - C = pressure coefficient. The pressure coefficient accounts for varying pressure across a surface.

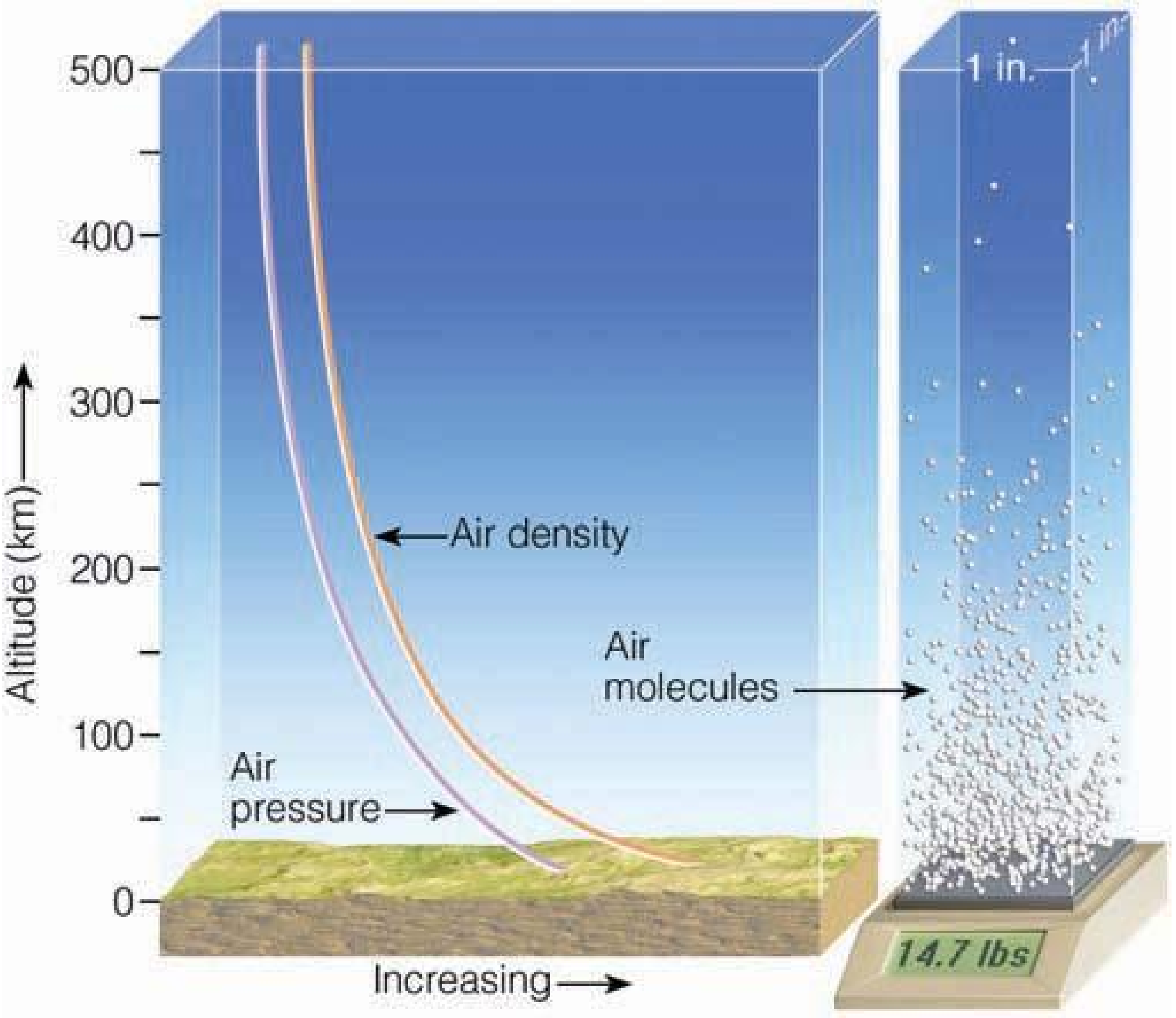
The Velocity Coefficient

$$p = \frac{1}{2}mV^2 = \frac{1}{2}\left[\frac{0.0765}{32.2}\right]\left[\frac{5280}{3600}\right]^2 V^2 = 0.0256V^2$$

See ASCE 7-05 C6.5.10

- Atmospheric pressure,
- 14.7 pound/square inch,
- 2.12 kip/square feet
- or nearly 1 ton/square feet

- Based on the average density of air at sea level, 0.0765 pound/cubic feet

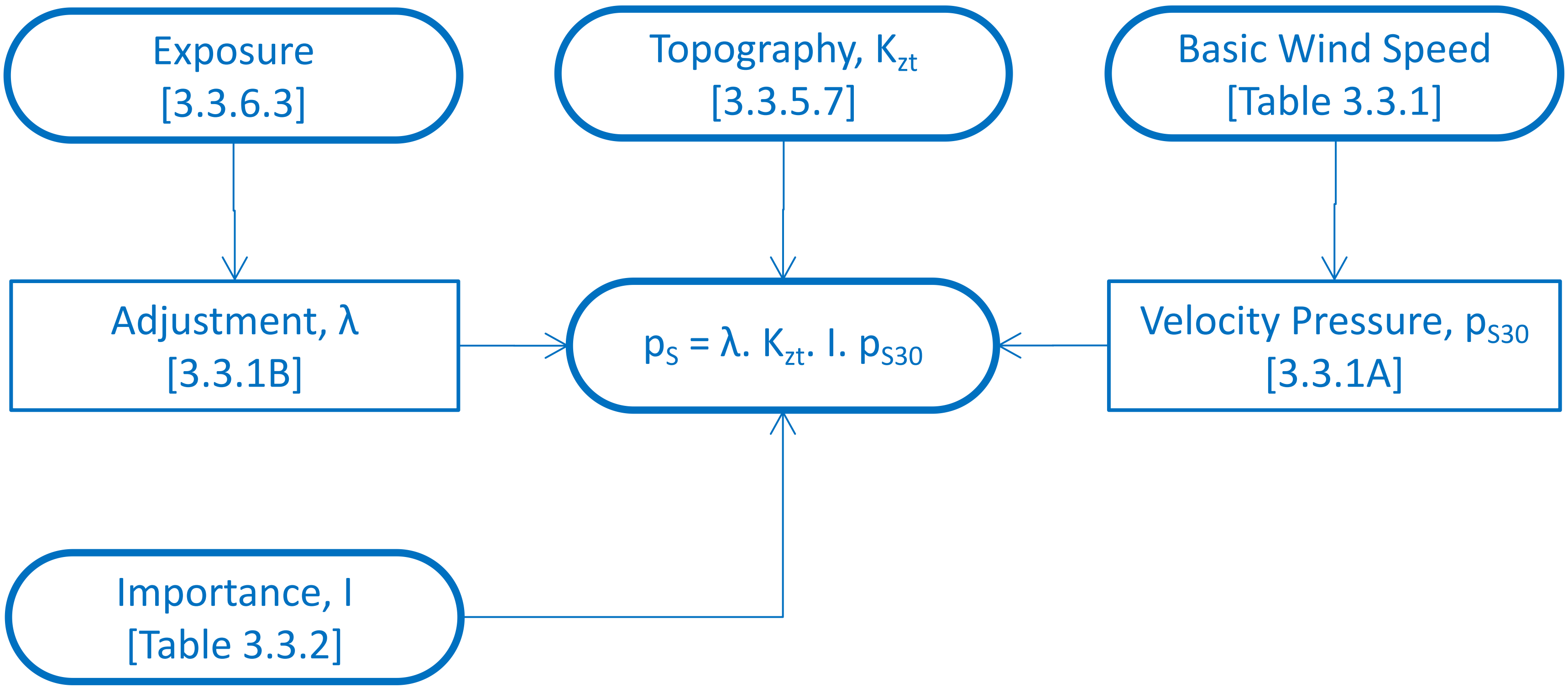


Velocity Pressure, q

See ASCE 7-05 6.5.10

- q_z =Velocity Pressure = $0.00256 K_z K_{zt} K_d V^2 I$ (lb/ft^2)
  - Constant 0.00256
  - V = Basic wind speed in mph
  - I = Importance Factor (i.e. different MRI)
  - K_z = Exposure Coefficient
  - K_{zt} = Topographical Factor
  - K_d = Wind Directionality Factor
- Evaluated at an elevation z:
  - $q_z = 0.00256 V^2 I K_z K_{zt} K_d$
- Evaluated at the building mean roof elevation, h:
  - $q_h = 0.00256 V^2 I K_h K_{ht} K_d$

Wind Design Flow Chart



Method 1: Simplified Procedure

Minimum Wind Pressure = 10 psf

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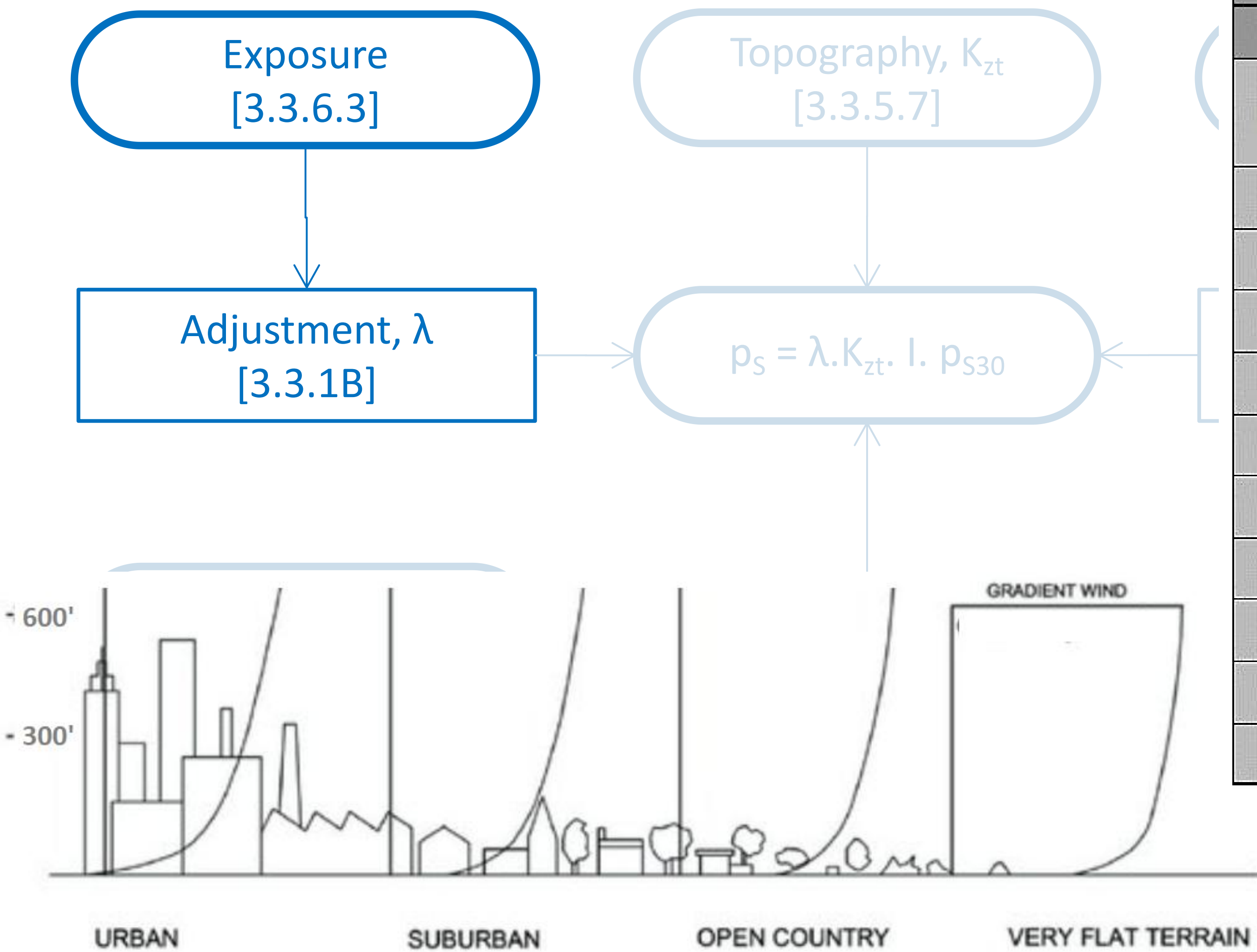
Exposure Factors



Surface Roughness B
Exposure B

Surface Roughness C
Exposure C

Surface Roughness D
Exposure D

Adjustment Factor for Building Height and Exposure, λ			
Mean Roof Height (ft)	Exposure		
	B	C	D
15	1.00	1.21	1.47
20	1.00	1.29	1.55
25	1.00	1.35	1.61
30	1.00	1.40	1.66
35	1.05	1.45	1.70
40	1.09	1.49	1.74
45	1.12	1.53	1.78
50	1.16	1.56	1.81
55	1.19	1.59	1.84
60	1.22	1.62	1.87

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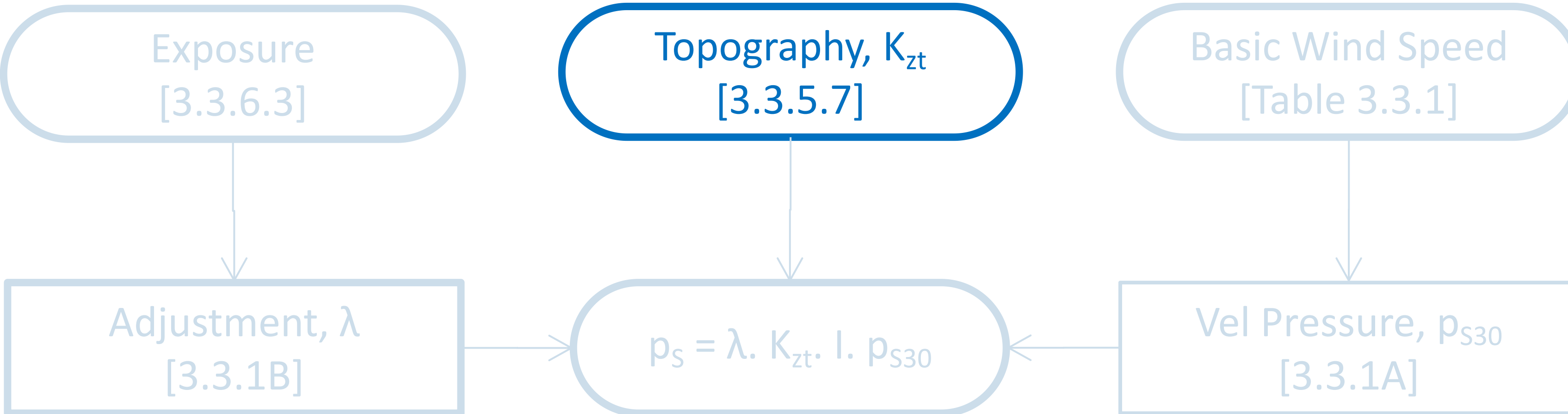
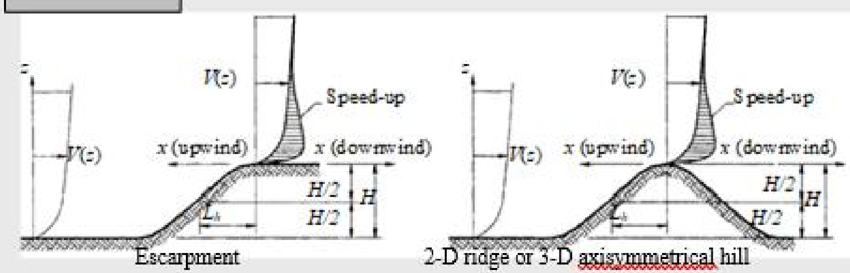
Topography Factor



Topographic Factor, K_{zt} - Method 2

Figure 3.3.3



Topographic multipliers for Exposure C										
	K_1 multiplier				K_2 multiplier			K_3 multiplier		
H/L_h	2-D ridge	2-D escarp.	3-D axisym. hill	x/L_h	2-D escarp.	All other cases	z/L_h	2-D ridge	2-D escarp.	3-D axisym. hill
0.20	0.29	0.17	0.21	0.00	1.00	1.00	0.00	1.00	1.00	1.00
0.25	0.36	0.21	0.26	0.50	0.88	0.67	0.10	0.74	0.78	0.67
0.30	0.43	0.26	0.32	1.00	0.75	0.33	0.20	0.55	0.61	0.45
0.35	0.51	0.30	0.37	1.50	0.63	0.00	0.30	0.41	0.47	0.30
0.40	0.58	0.34	0.42	2.00	0.50	0.00	0.40	0.30	0.37	0.20
0.45	0.65	0.38	0.47	2.50	0.38	0.00	0.50	0.22	0.29	0.14

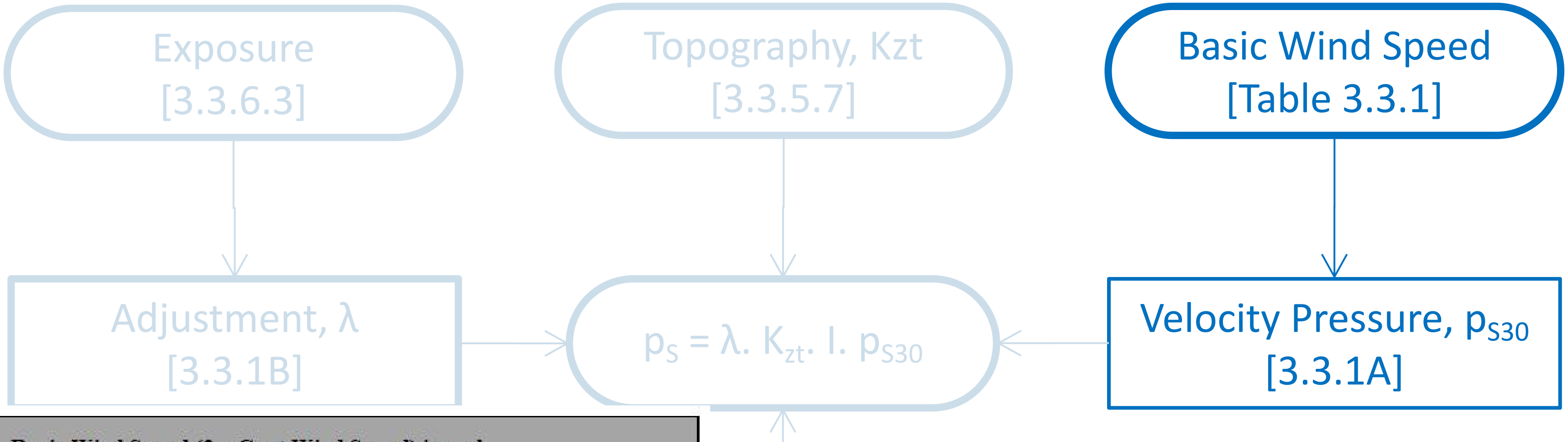
Topographic Factor, K_{zt} - Method 2

Figure 3.3.3 (contd.)

$K_{zt} = (1+K_1K_2K_3)^2$, K_1 determined from table below, $K_2 = (1 - \frac{|x|}{\mu L_h})$, $K_3 = e^{-\gamma z/L_h}$

Parameters for speed-up over hills and escarpments						
Hill shape	$K_1/(H/L_h)$			γ	μ	
	Exposure				Upwind of crest	Downwind of crest
	B	C	D			
2-dimensional ridges (or valleys with negative H in $K_1/(H/L_h)$)	1.30	1.45	1.55	3	1.5	1.5
2-dimensional escarpments	0.75	0.85	0.95	2.5	1.5	4
3-dimensional axisym. hill	0.95	1.05	1.15	4	1.5	1.5

Basic Wind Speed



Basic Wind Speed (3-s Gust Wind Speed) in mph

Table 3.3.1

Sr. No.	City/Town	Basic Wind Speed (mph)
1	Sittwe (Akyab)	140
2	Kyaukpyu (Kyaukphyu)	140
3	Thandwe (Sandoway)	140
4	Pathein (Bassein)	120
5	Bogalay	120
6	Yangon (Rangoon)	120
7	Mawlamyine (Mawlamyaing)	100
8	Ye	100
9	Dawei (Tavoy)	100
10	Myeik (Mergui)	100
11	Kawthaung	100
12	Bago (Pegu)	100

Main Wind Force Resisting Syatem - Method 1 | **$h \leq 60$ ft**

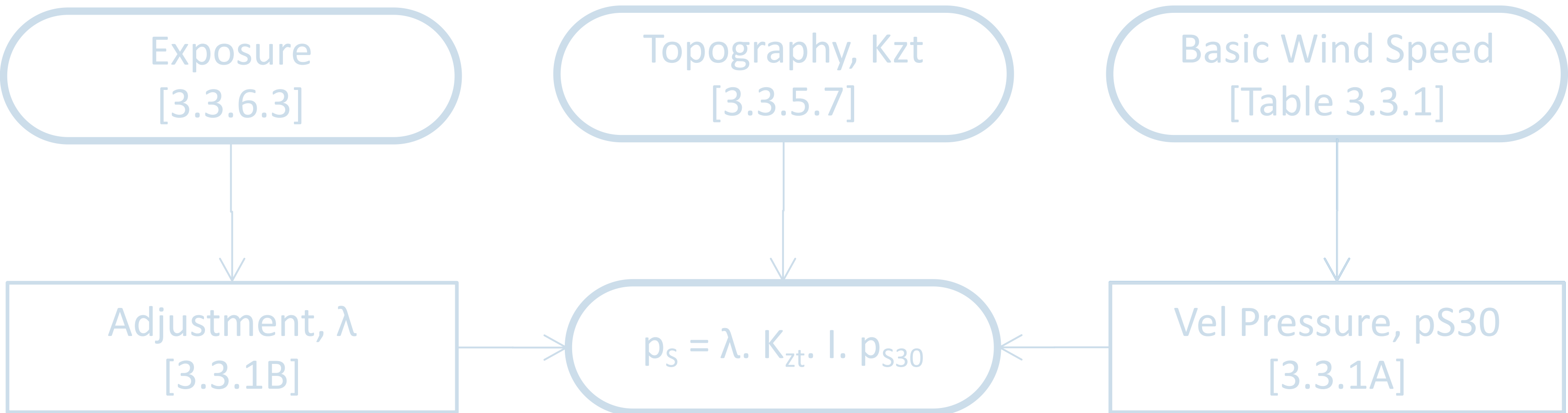
Figure 3.3.1 (cont'd) | **Design Wind Pressures** | **Walls & Roofs**

Enclosed Buildings

Simplified Design Wind Pressure, p_{s30} (psf) *(Exposure B at h = 30 ft, K_{zt} = 1.0, with I = 1.0)*

Basic Wind Speed (mph)	Roof Angle (degrees)	Load Case	Zones									
			Horizontal Pressures				Vertical Pressures				Overhangs	
			A	B	C	D	E	F	G	H	E_{OH}	G_{OH}
125	0 to 5°	1	24.7	-12.9	16.4	-7.6	-29.7	-16.9	-20.7	-13.1	-41.7	-32.7
	10°	1	28.0	-11.6	18.6	-6.7	-29.7	-18.2	-20.7	-14.0	-41.7	-32.7
	15°	1	31.1	-10.3	20.7	-5.9	-29.7	-19.4	-20.7	-14.9	-41.7	-32.7
	20°	1	34.3	-9.0	22.9	-5.0	-29.7	-20.7	-20.7	-15.7	-41.7	-32.7
	25°	1	31.0	5.0	22.5	5.1	-13.8	-18.8	-10.0	-15.1	-25.7	-21.9
		2	—	—	—	—	-5.2	-10.2	-1.4	-6.5	—	—
	30 to 45°	1	27.9	19.1	22.1	15.2	2.2	-16.9	0.8	-14.5	-9.8	-11.2
		2	27.9	19.1	22.1	15.2	10.7	-8.4	9.3	-6.0	-9.8	-11.2
130	0 to 5°	1	26.8	-13.9	17.8	-8.2	-32.2	-18.3	-22.4	-14.2	-45.1	-35.3
	10°	1	30.2	-12.5	20.1	-7.3	-32.2	-19.7	-22.4	-15.1	-45.1	-35.3
	15°	1	33.7	-11.2	22.4	-6.4	-32.2	-21.0	-22.4	-16.1	-45.1	-35.3
	20°	1	37.1	-9.8	24.7	-5.4	-32.2	-22.4	-22.4	-17.0	-45.1	-35.3
	25°	1	33.6	5.4	24.3	5.5	-14.9	-20.4	-10.8	-16.4	-27.8	-23.7
		2	—	—	—	—	-5.7	-11.1	-1.5	-7.1	—	—
	30 to 45°	1	30.1	20.6	24.0	16.5	2.3	-18.3	0.8	-15.7	-10.6	-12.1
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Importance Factor



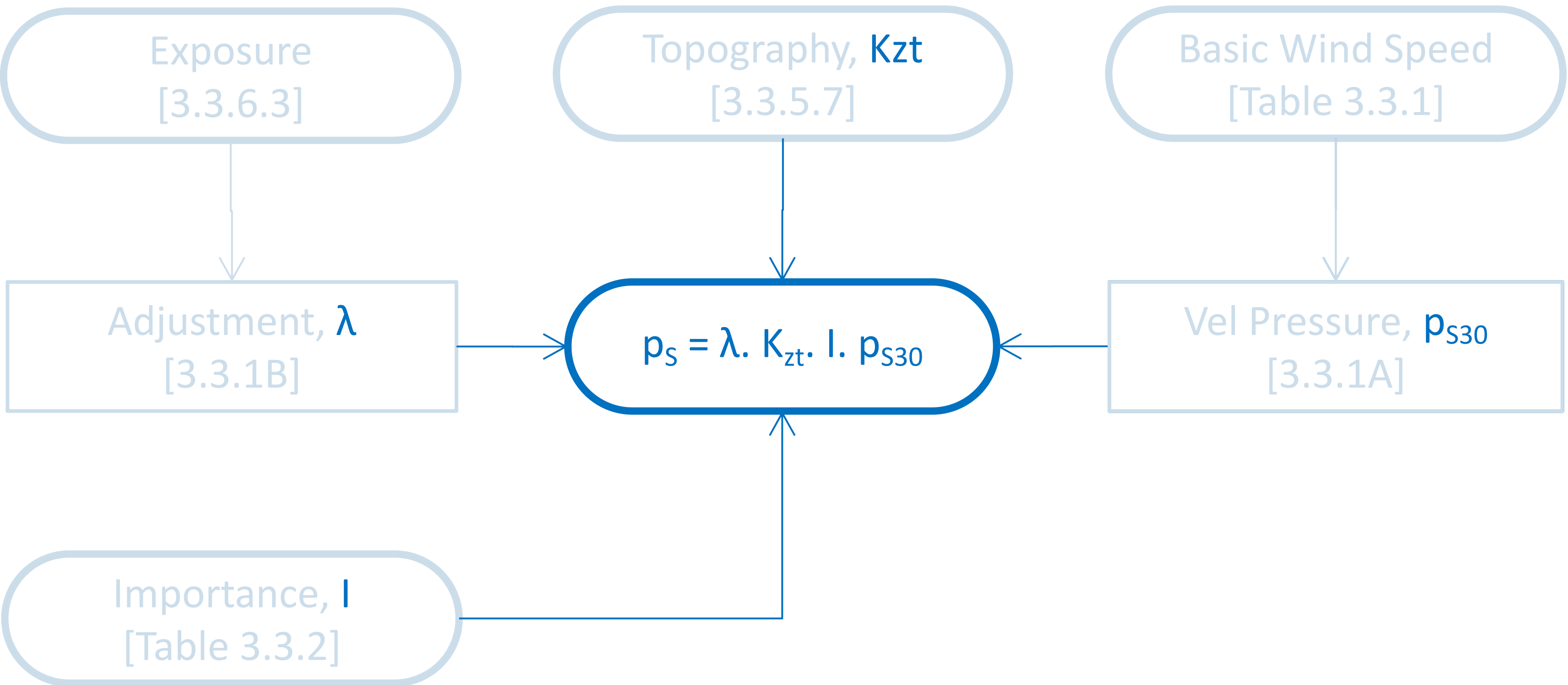
Importance, I
[Table 3.3.2]

Importance Factor, I (Wind Loads)

Table 3.3.2

Category	Non-Cyclone Prone Regions and CycloneProne Regions with V = 85-100 mph and Alaska	Cyclone Prone Regions with V > 100 mph
I	0.87	0.77
II	1	1
III	1.15	1.15
IV	1.15	1.15

Wind Pressure



Earthquake Load

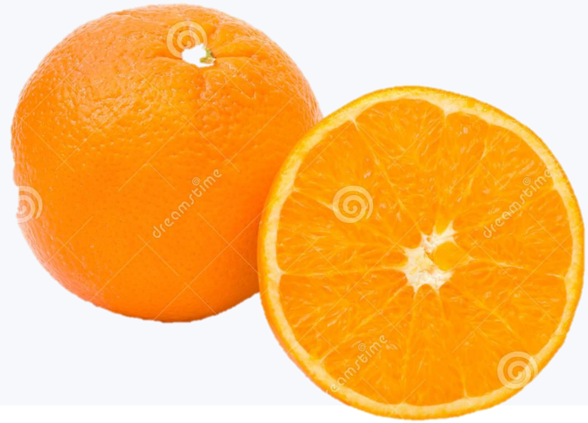
Earthquake Characterization

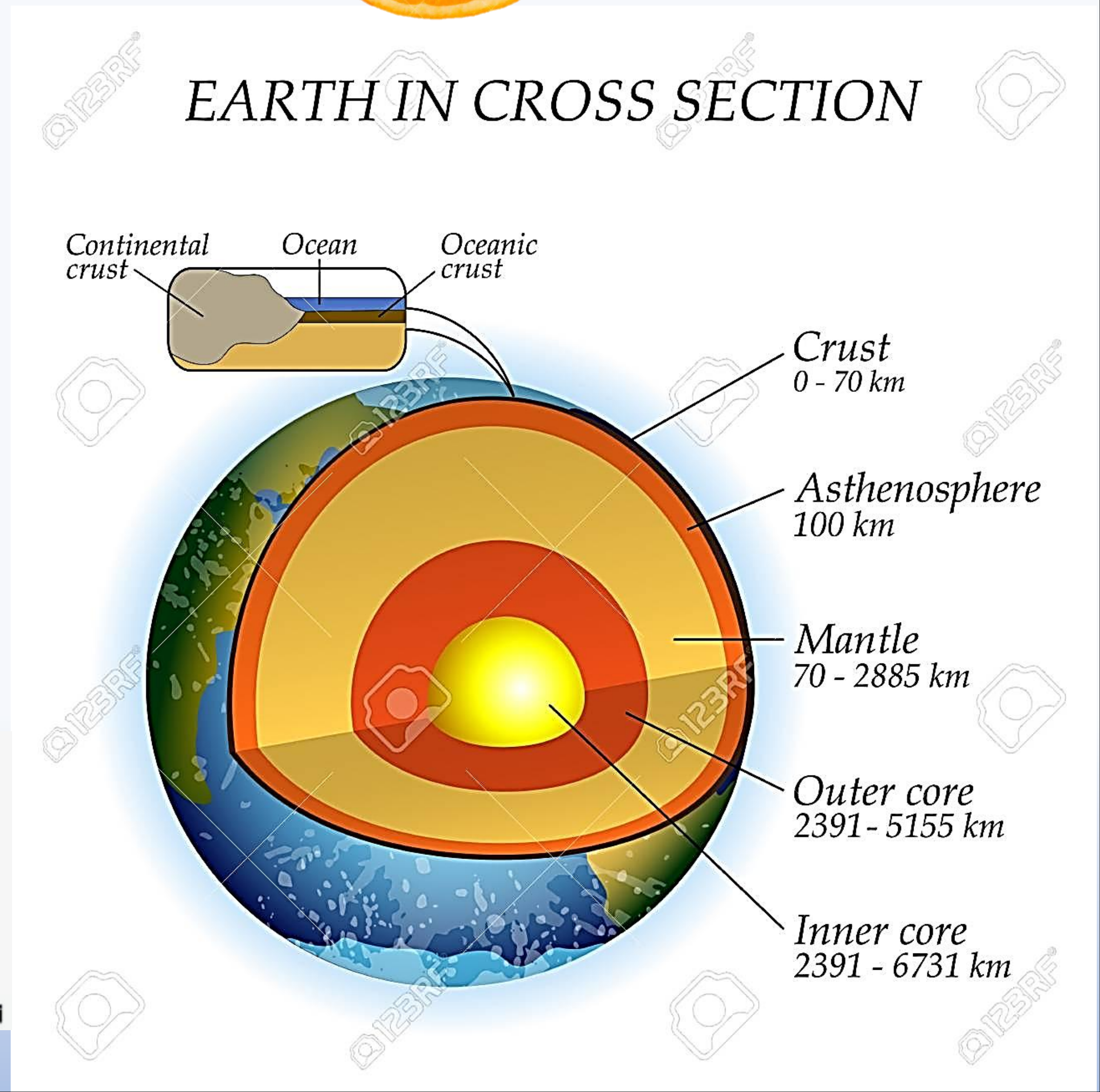
Earthquake Design Flow Chart

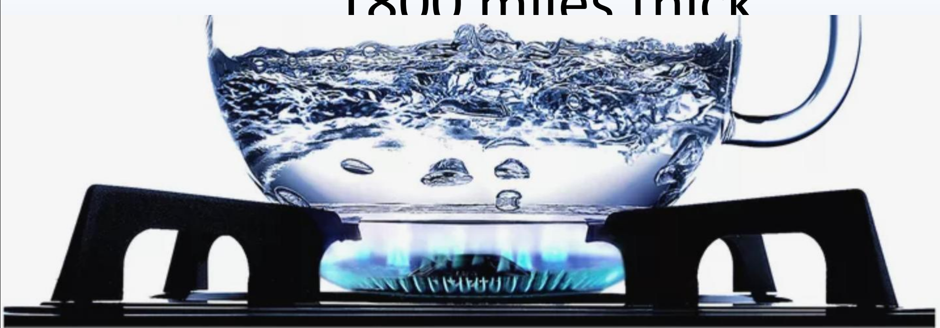
How the earth is made of?

Section Cut

- **Crust** – uppermost thin layer, 3-44 miles thick
- **Upper Mantle** – 200-250 miles thick, 1600 ˚F
- Lower Mantle – 1800 miles thick

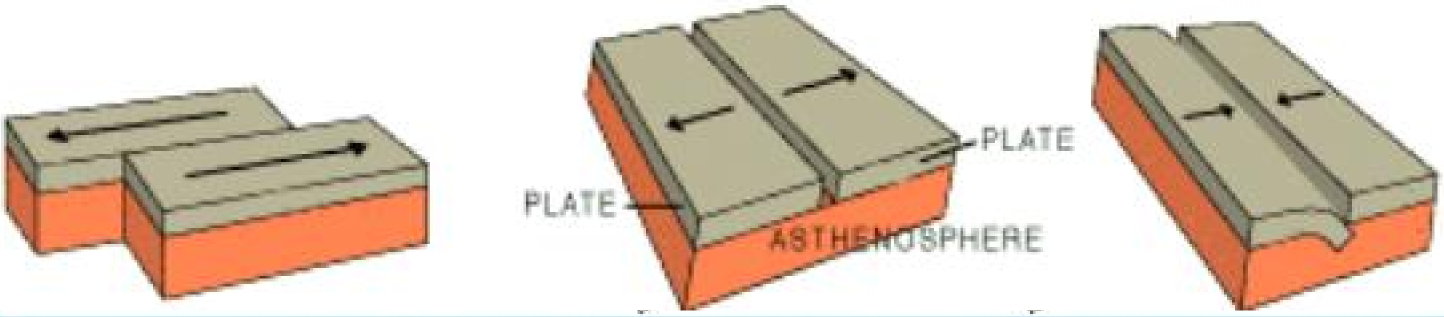


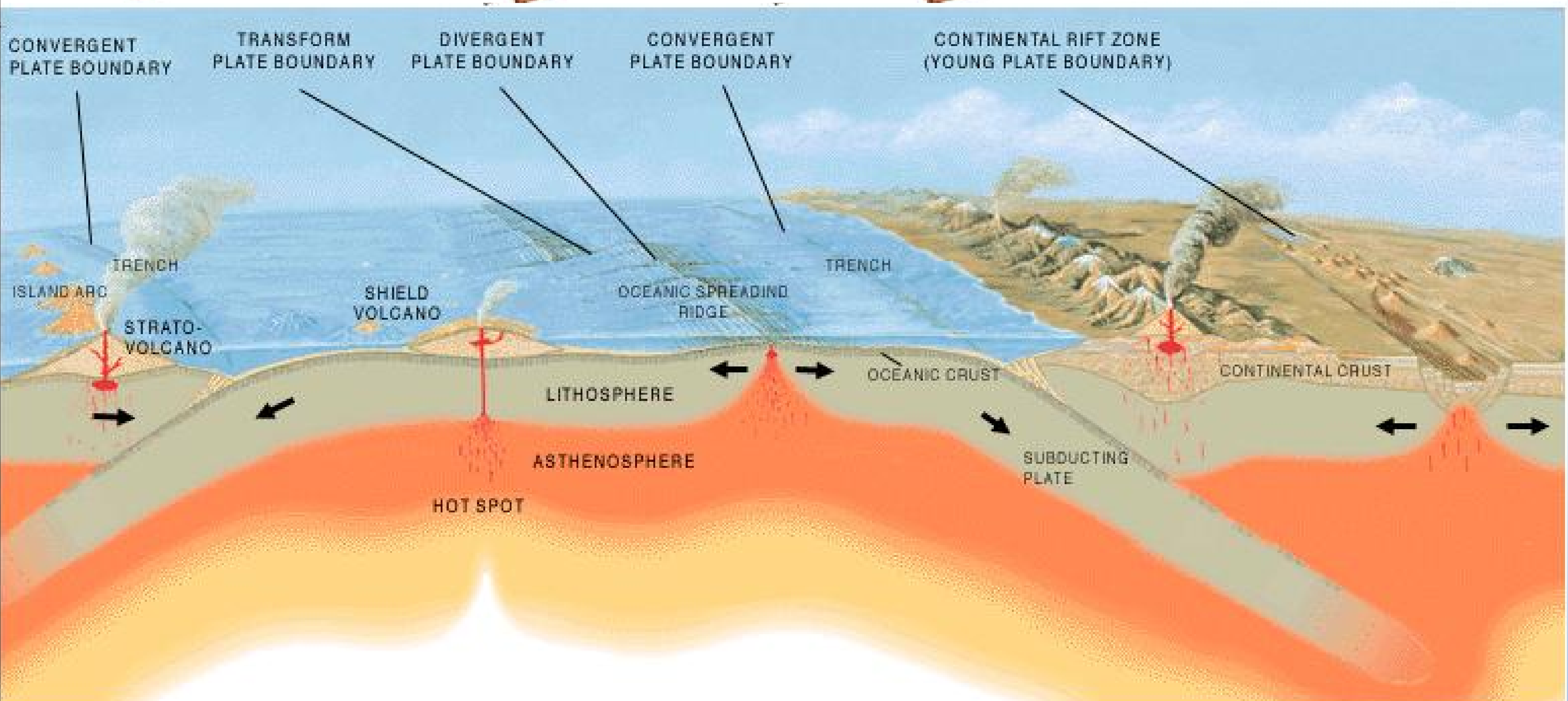


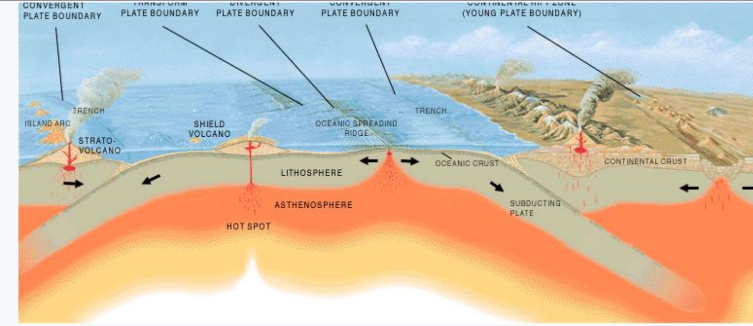


miles thick, 7000

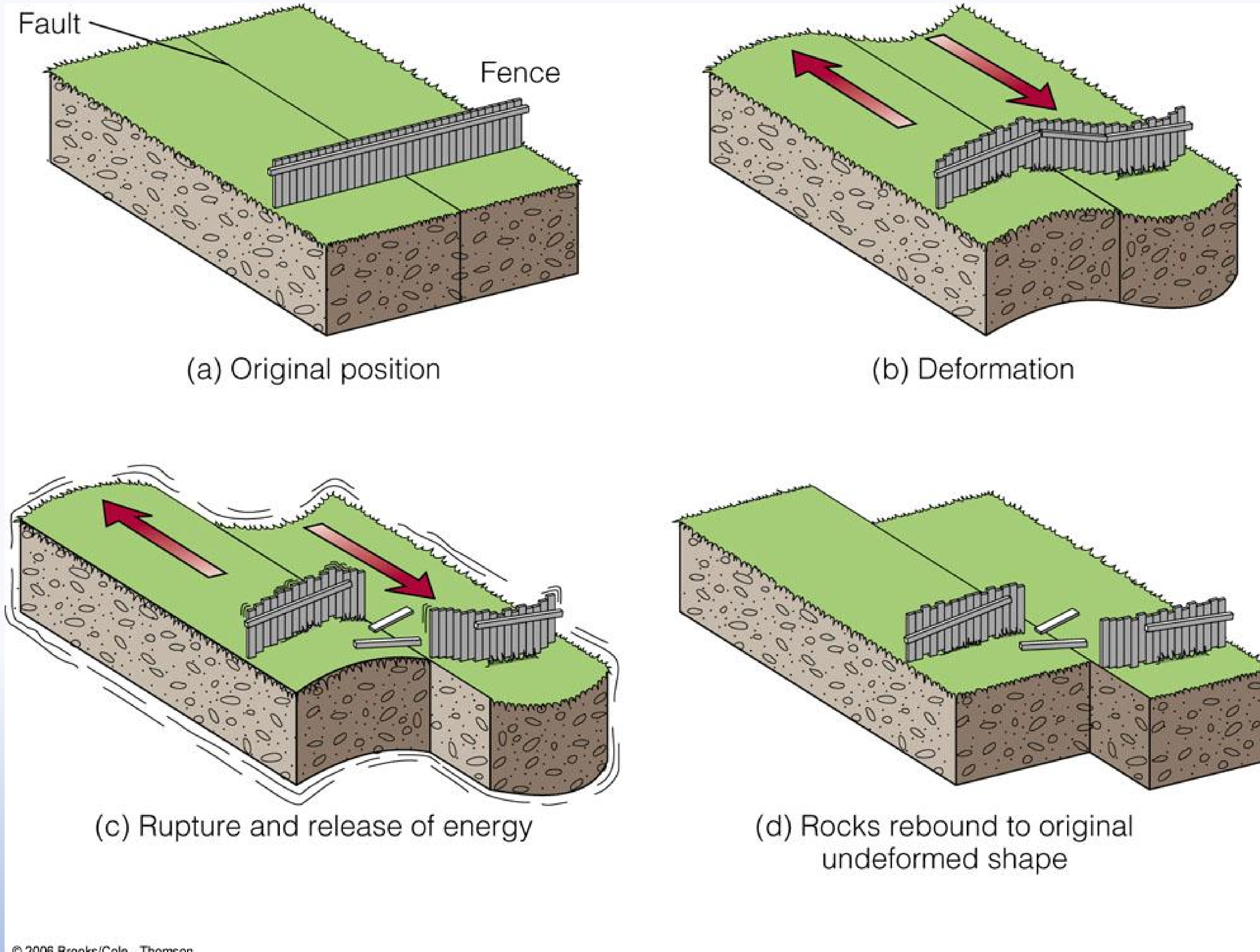
Why earthquakes happen?



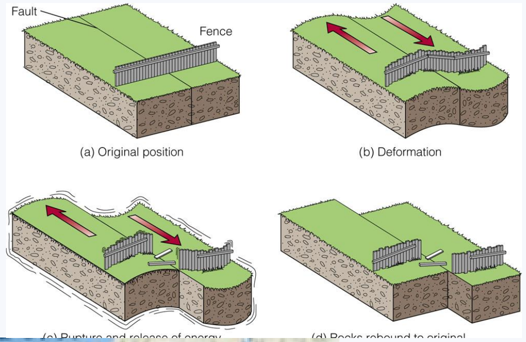


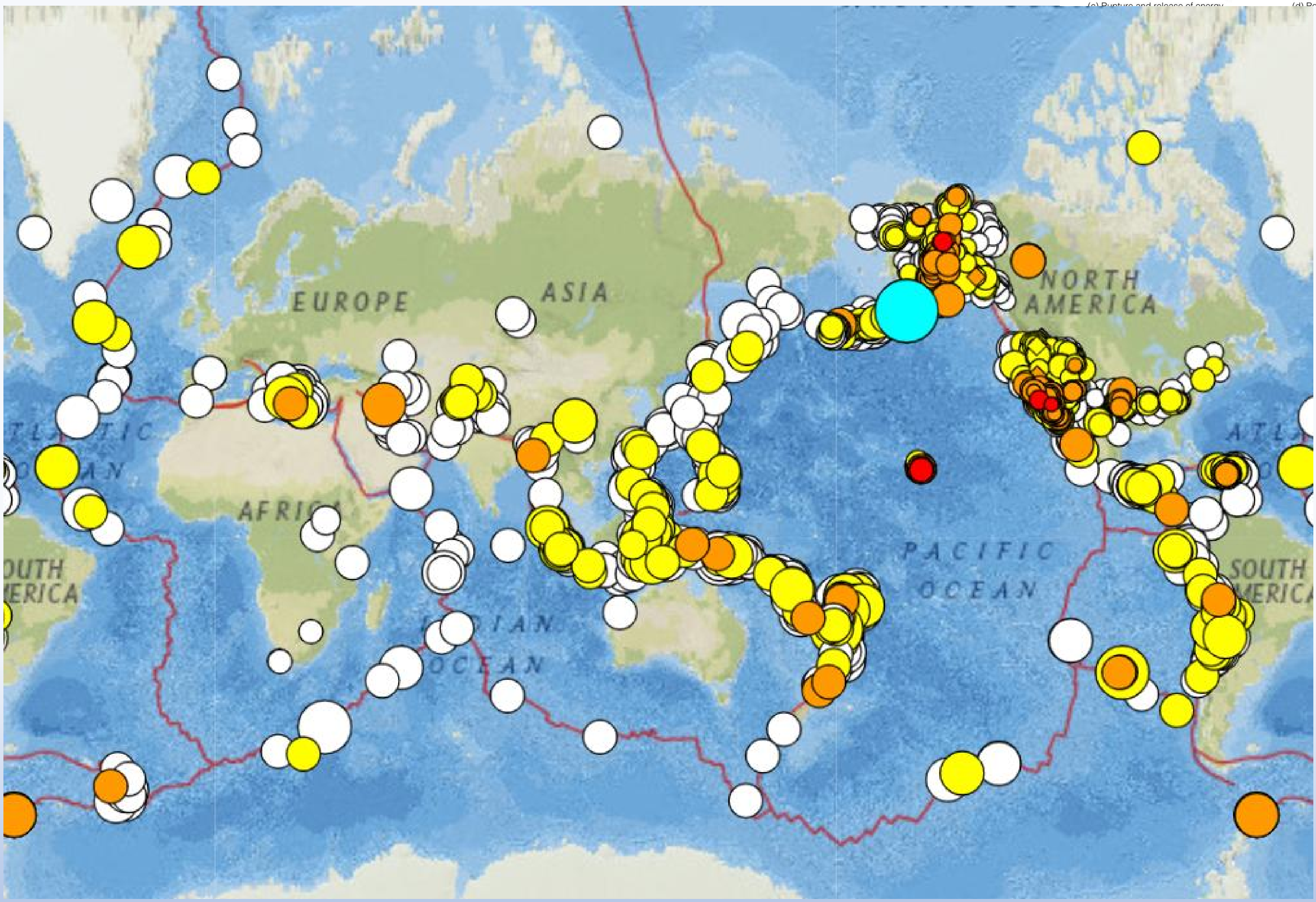


CONVERGENT
PLATE BOUNDARY
PLATE BOUNDARY
PLATE BOUNDARY
PLATE BOUNDARY
(YOUNG PLATE BOUNDARY)
TRENCH
ISLAND ARC
STRATO-VOLCANO
SHIELD VOLCANO
OCEANIC SPREADING RIDGE
TRENCH
OCEANIC CRUST
CONTINENTAL CRUST
LITHOSPHERE
ASTHENOSPHERE
HOT SPOT
SUBDUCTING PLATE

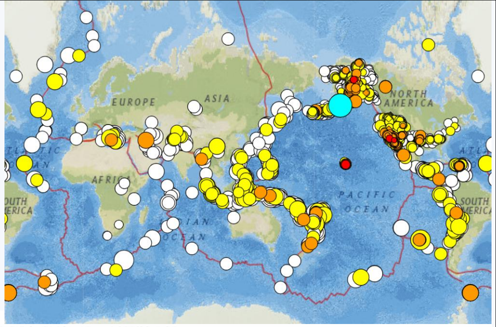


Fault
Fence
(a) Original position
(b) Deformation
(c) Rupture and release of energy
(d) Rocks rebound to original undeformed shape
© 2006 Brooks/Cole - Thomson


Fault
Fence
(a) Original position
(b) Deformation


EUROPE
ASIA
NORTH AMERICA
PACIFIC OCEAN

How do we measure an earthquake?

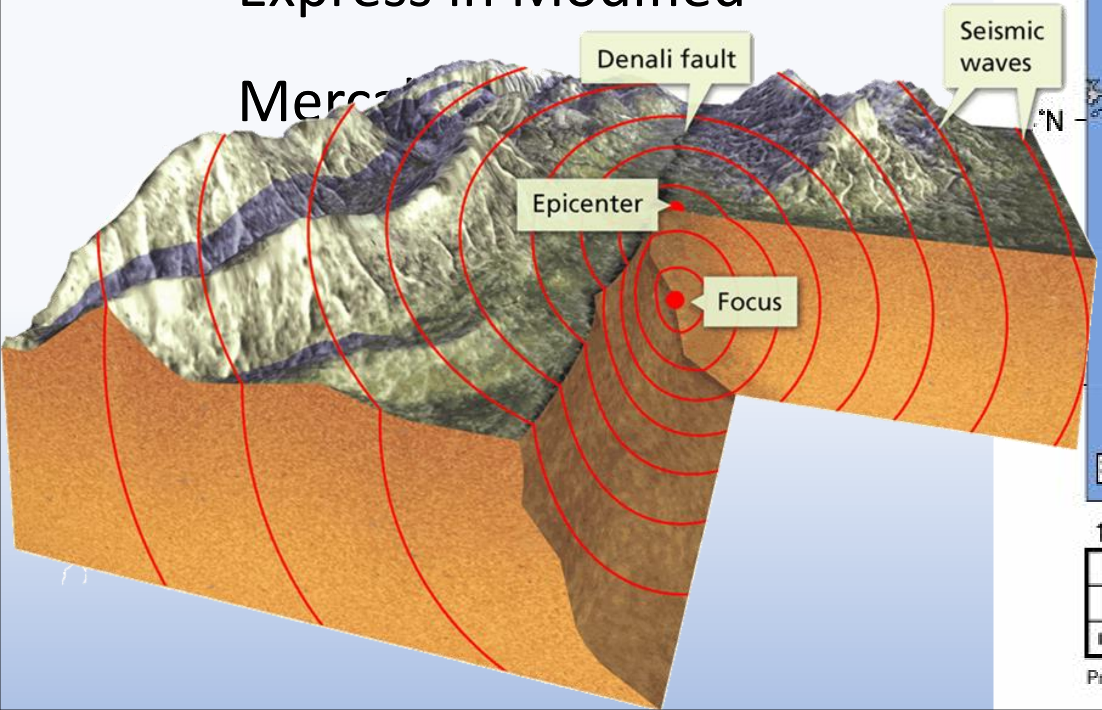


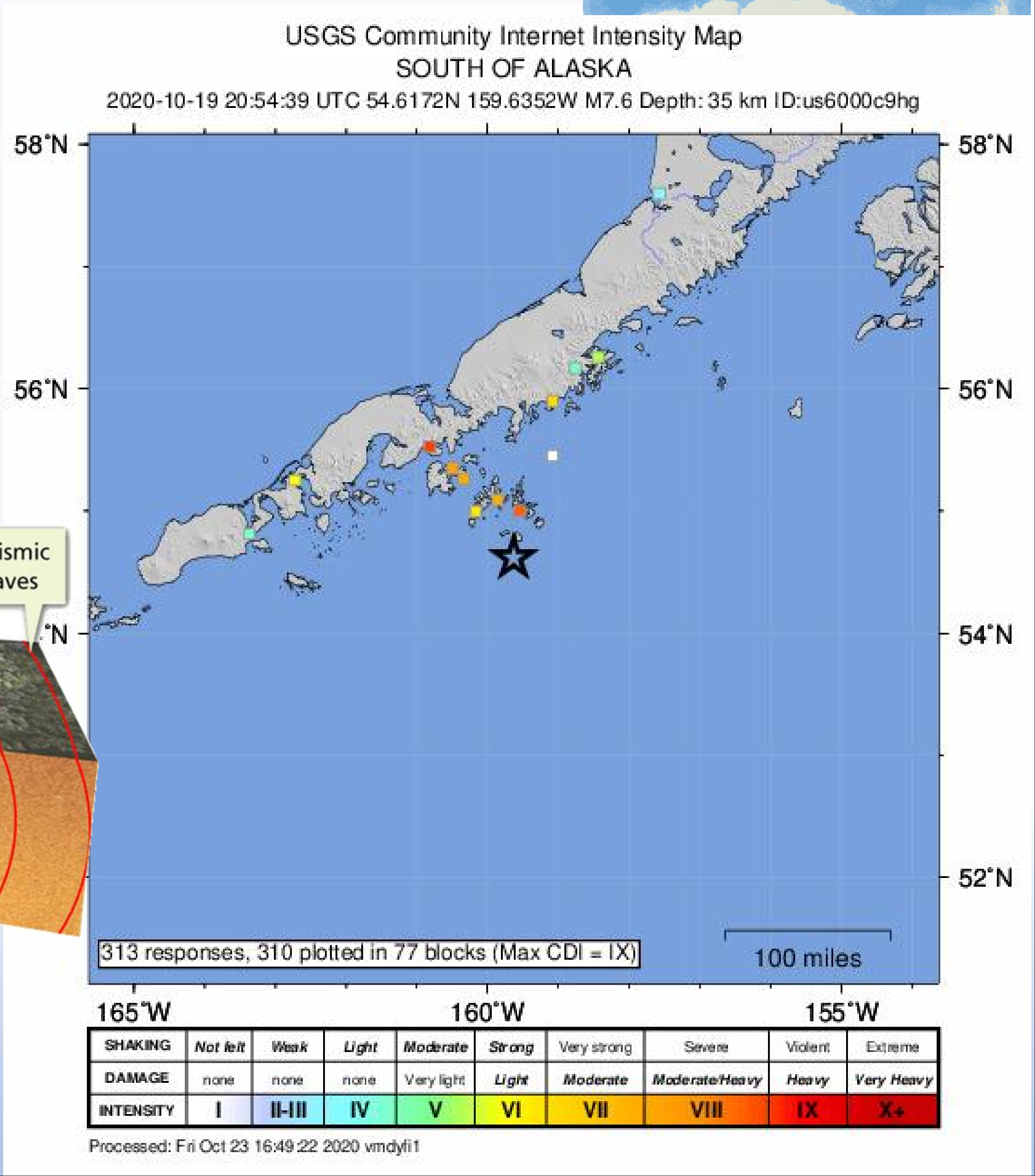
MAGNITUDE

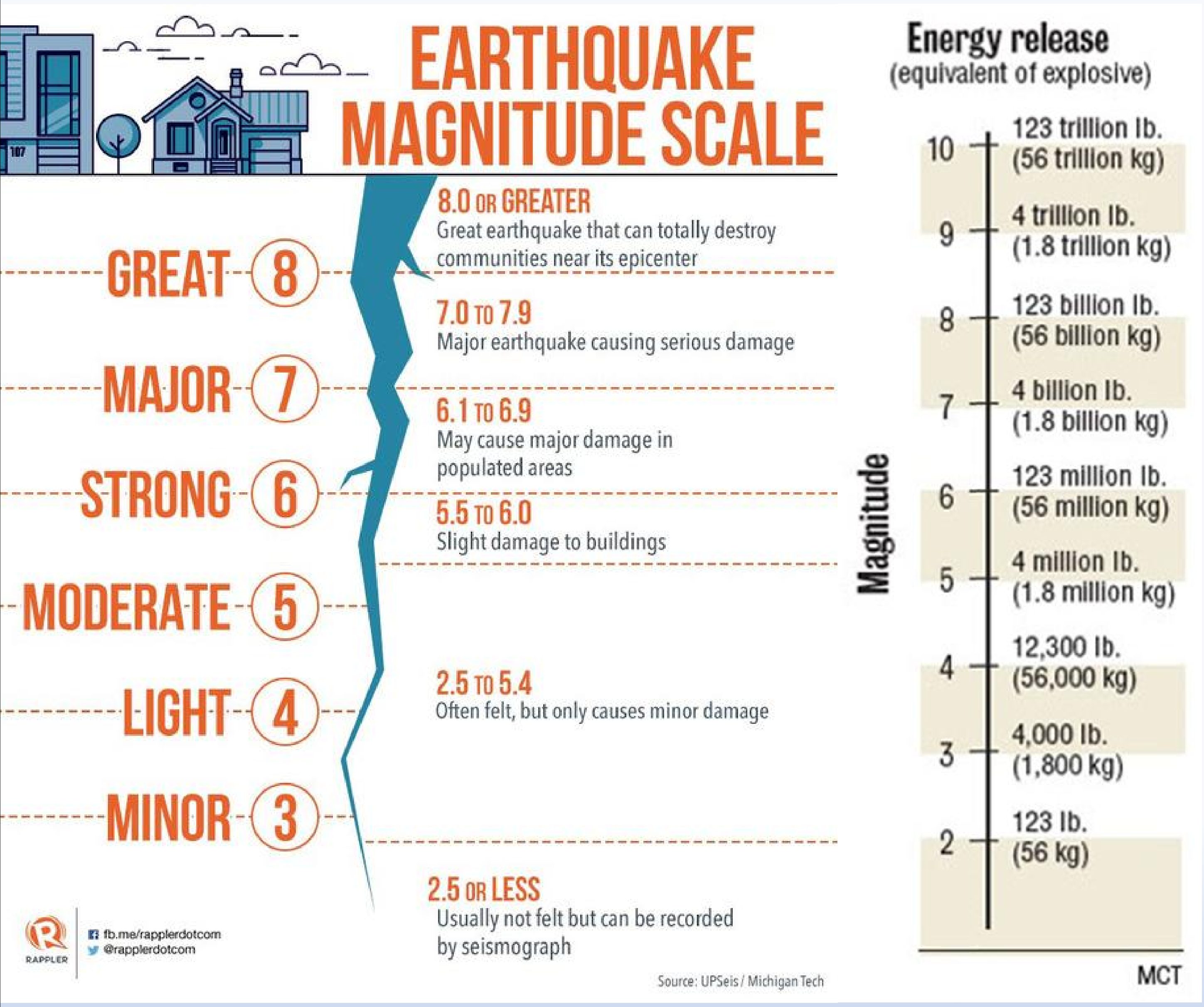
- Express in Richter Scale
- Cause
- Size of the event

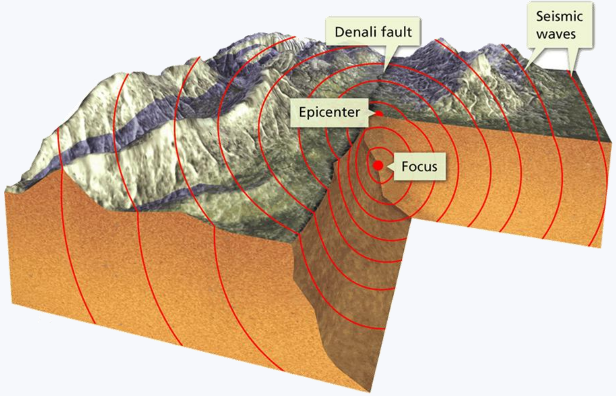
INTENSITY

- Express in Modified Merca



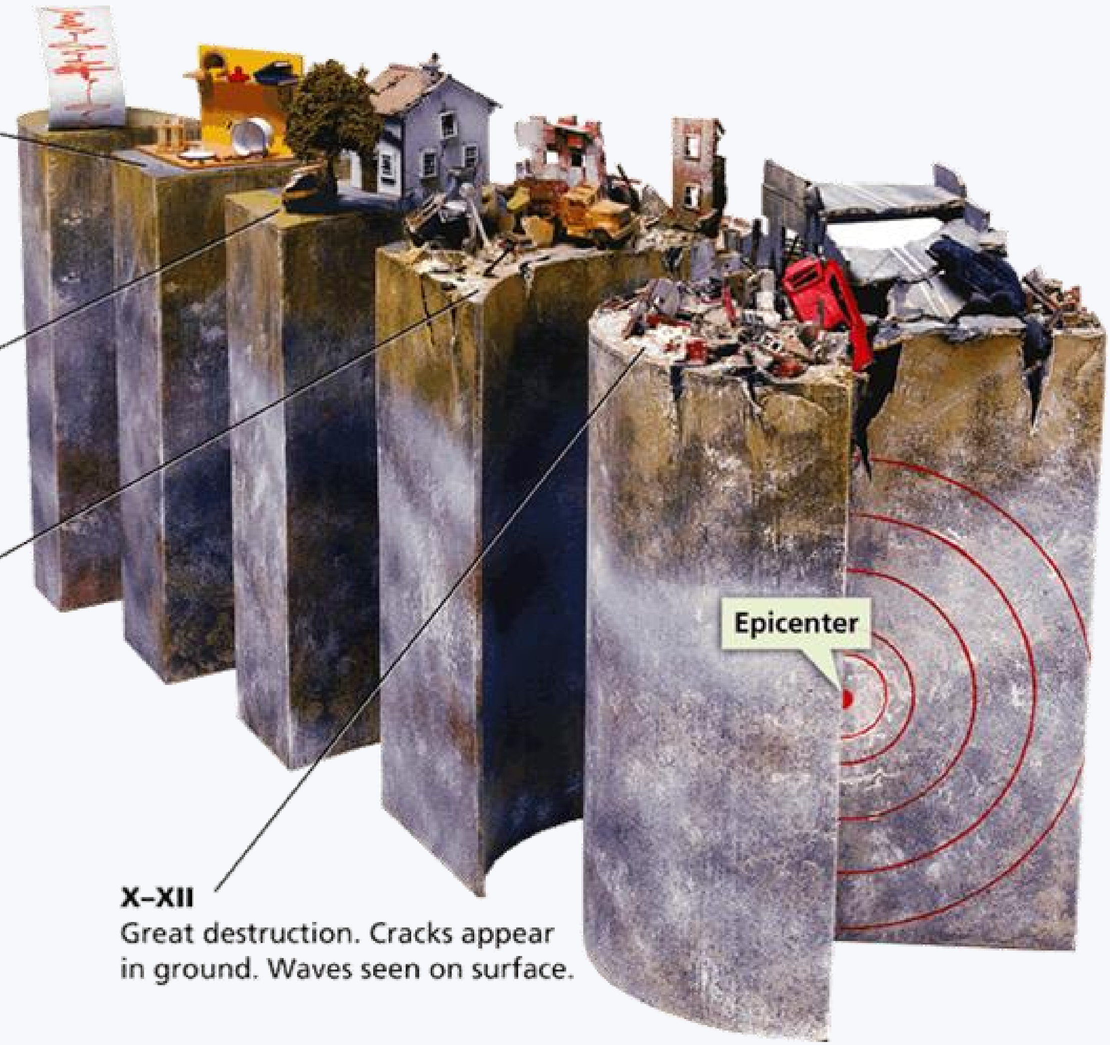


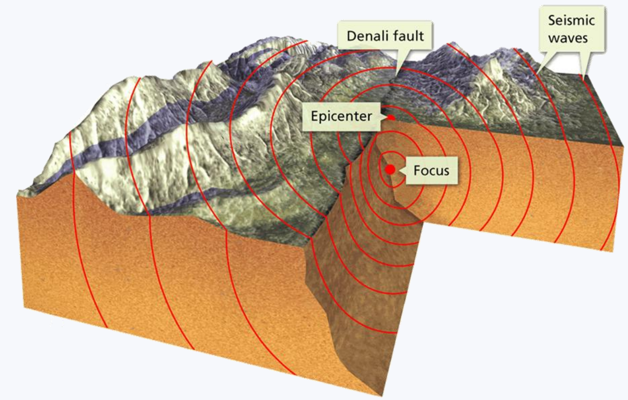




MAGNITUDE

- Express in Richter Scale
- Cause
- Size of the event
- Interest of the Scientists





INTENSITY

- Express in Modified Mercalli Scale
- Effect
- Damage potential

INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+
Shaking	Not felt	Weak	Light	Moderate	Strong	Very Strong	Severe	Violent	Extreme
Damage	None	None	None	Very slight	Light	Moderate	Moderate/ heavy	Heavy	Very heavy
Peak Acc	<0.17	0.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
Peak Vel	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16 -31	31-60	60-116	>116

Peak Acc = Peak ground acceleration (g), Peak Vel = Peak ground velocity (cm/s)

Ground Shaking, Magnitude, Intensity

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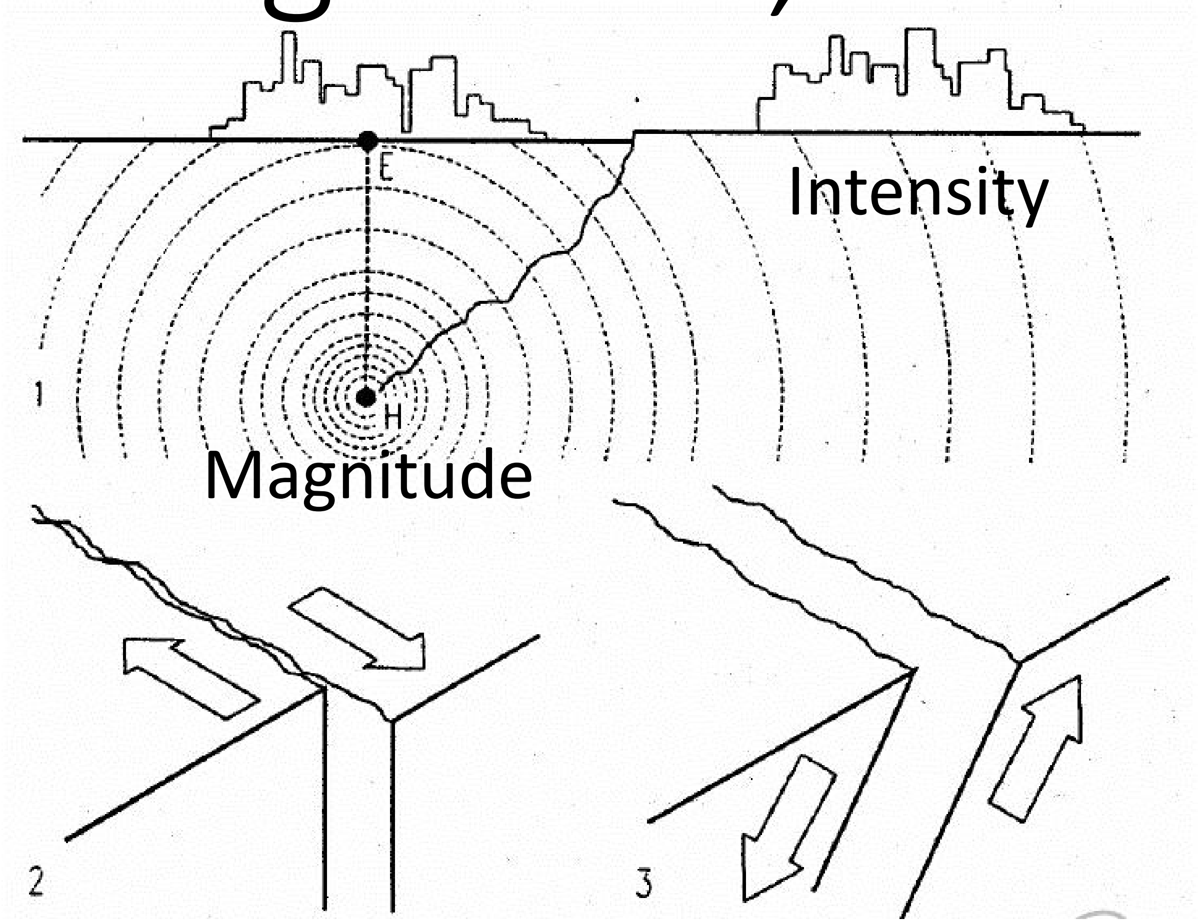
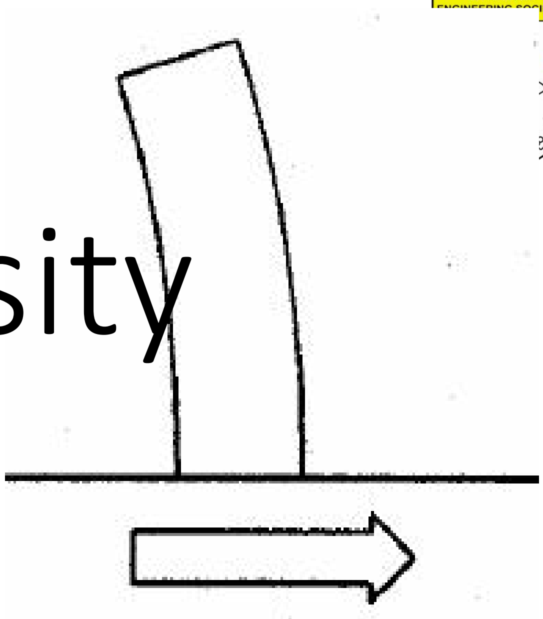
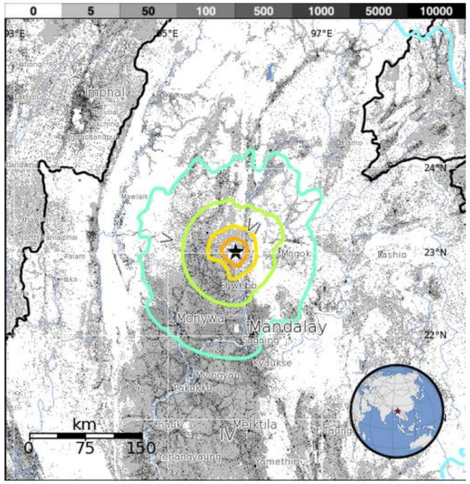




- Sudden earth shaking applies at the base of the buildings

Population Exposure

Population per ~1 sq. km. from LandScan



Structure Information Summary

Overall, the population in this region resides in structures that are highly vulnerable to earthquake shaking, though some resistant structures exist.

Secondary Effects

Recent earthquakes in this area have caused secondary hazards such as landslides that might have contributed to losses.

Selected Cities Exposed

from GeoNames Database of Cities with 1,000 or more residents.

MMI	City	Population
VI	Shwebo	88k
V	Mogok	90k
V	Mandalay	1,208k
V	Maymyo	117k
V	Monywa	182k
V	Sagaing	78k
IV	Imphal	223k
IV	Myitkyina	90k
IV	Haka	0
IV	Taunggyi	160k
IV	Kohima	92k

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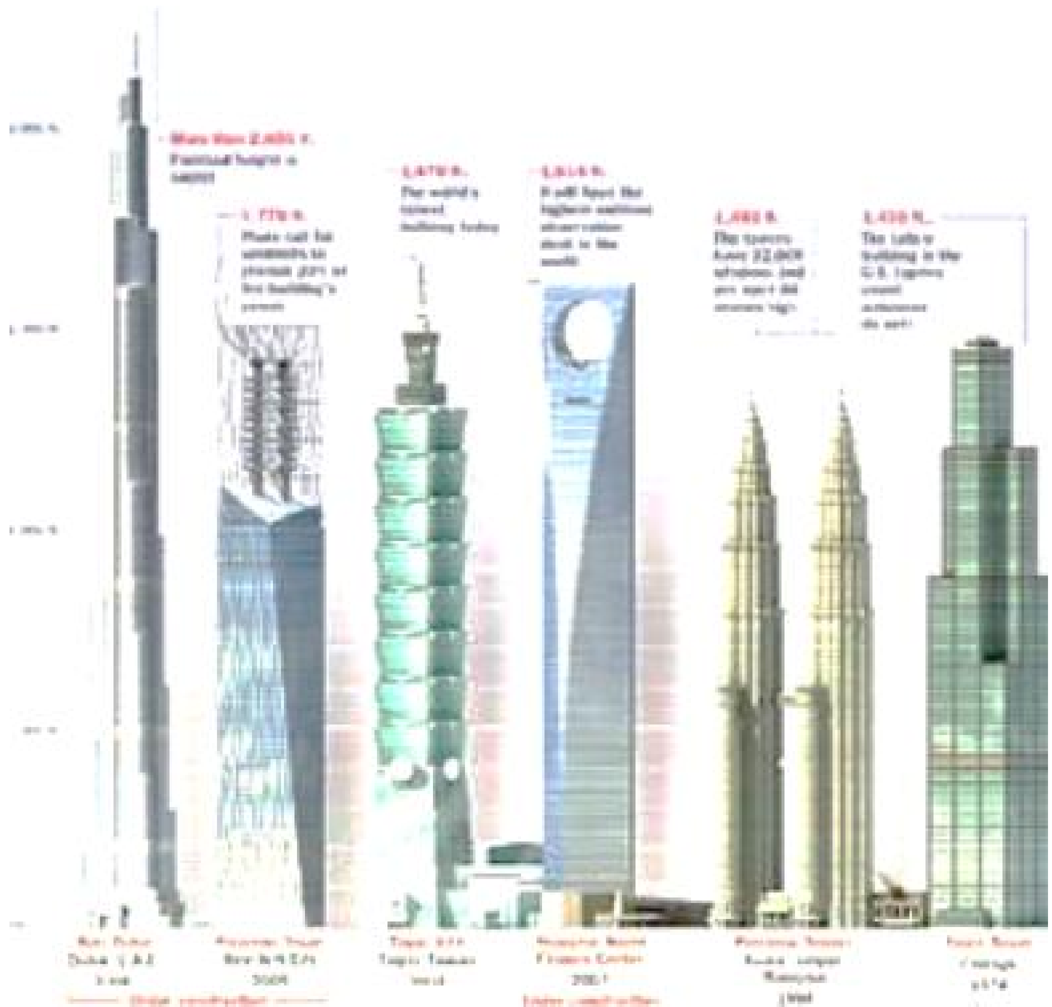
Seismic Response



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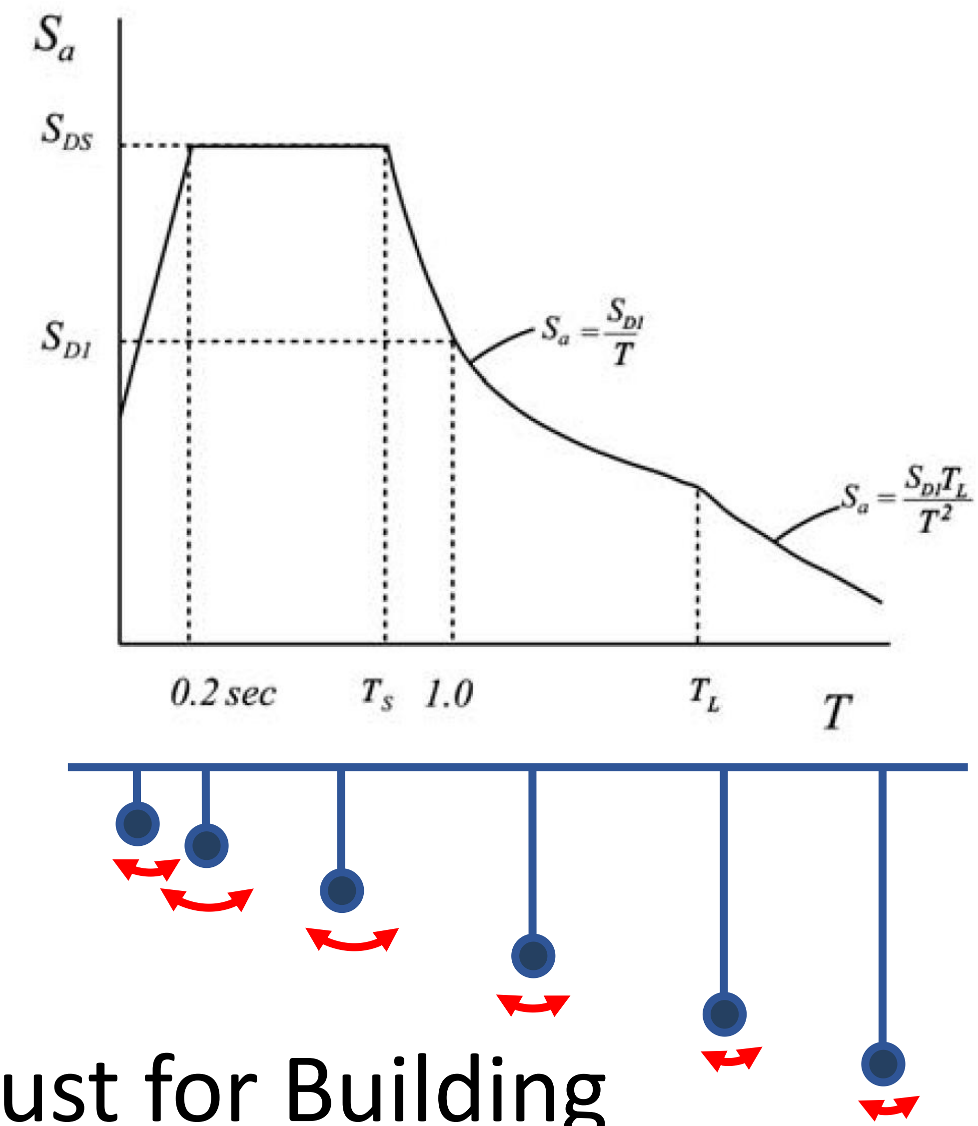
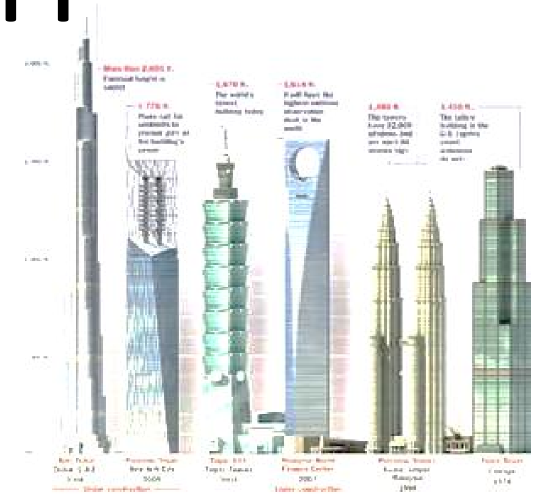
Response Spectrum





Adjust for Building Period

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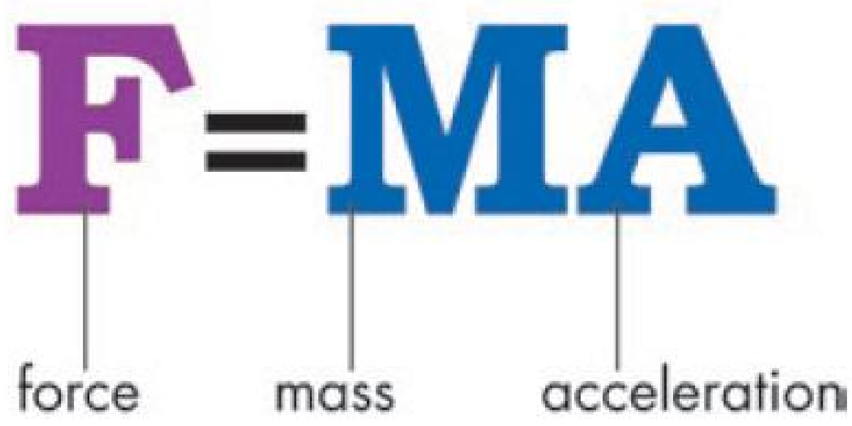
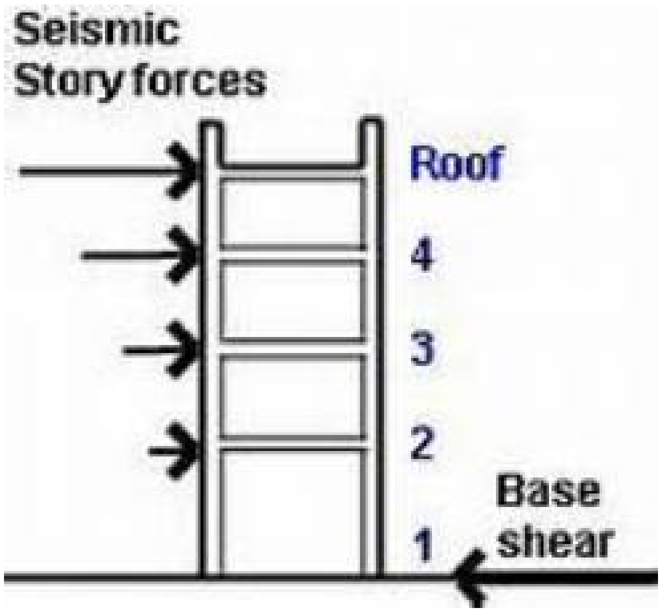
Seismic Forces





- Apply to each level with respect of its story mass.
- Total story forces = Base Shear

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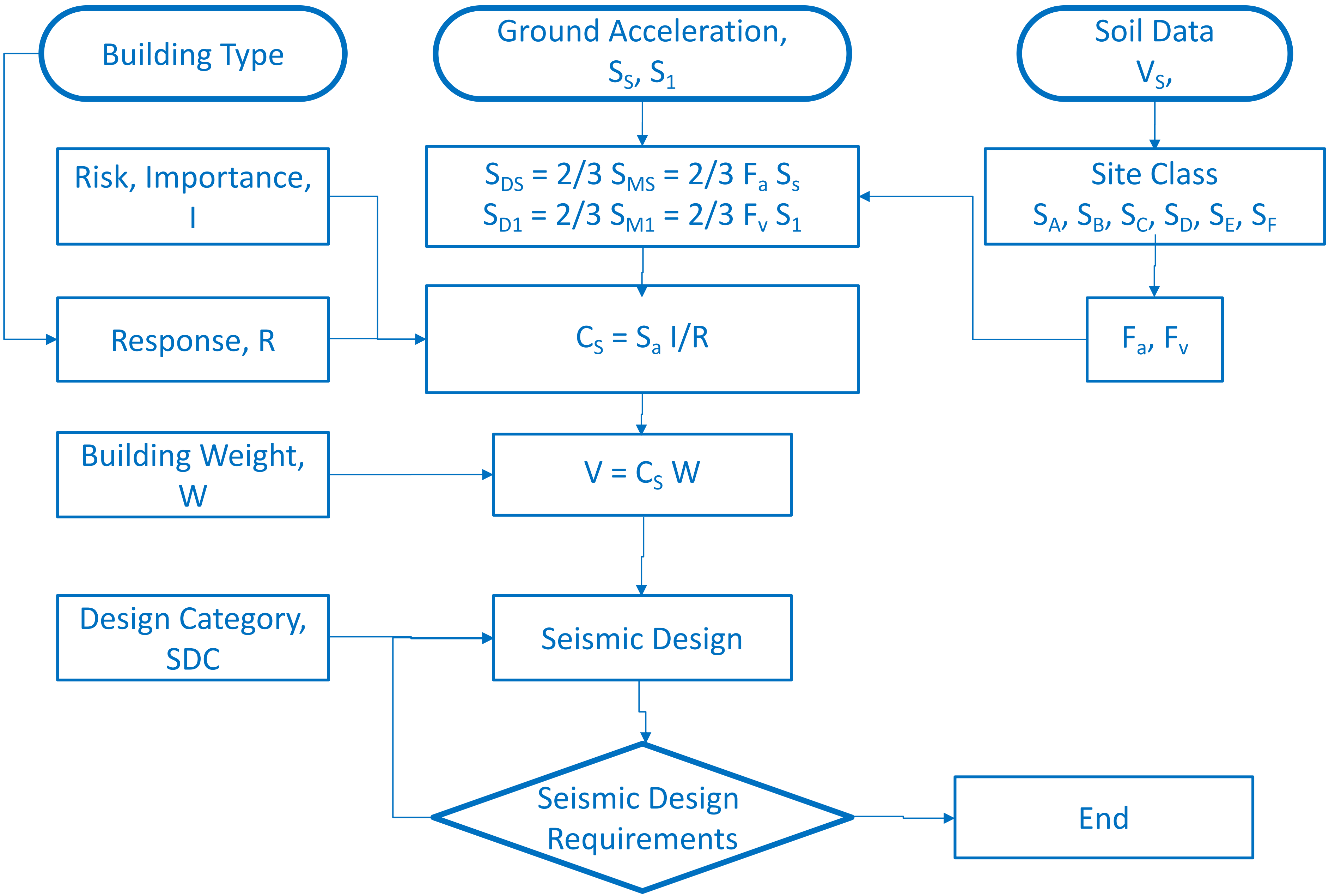
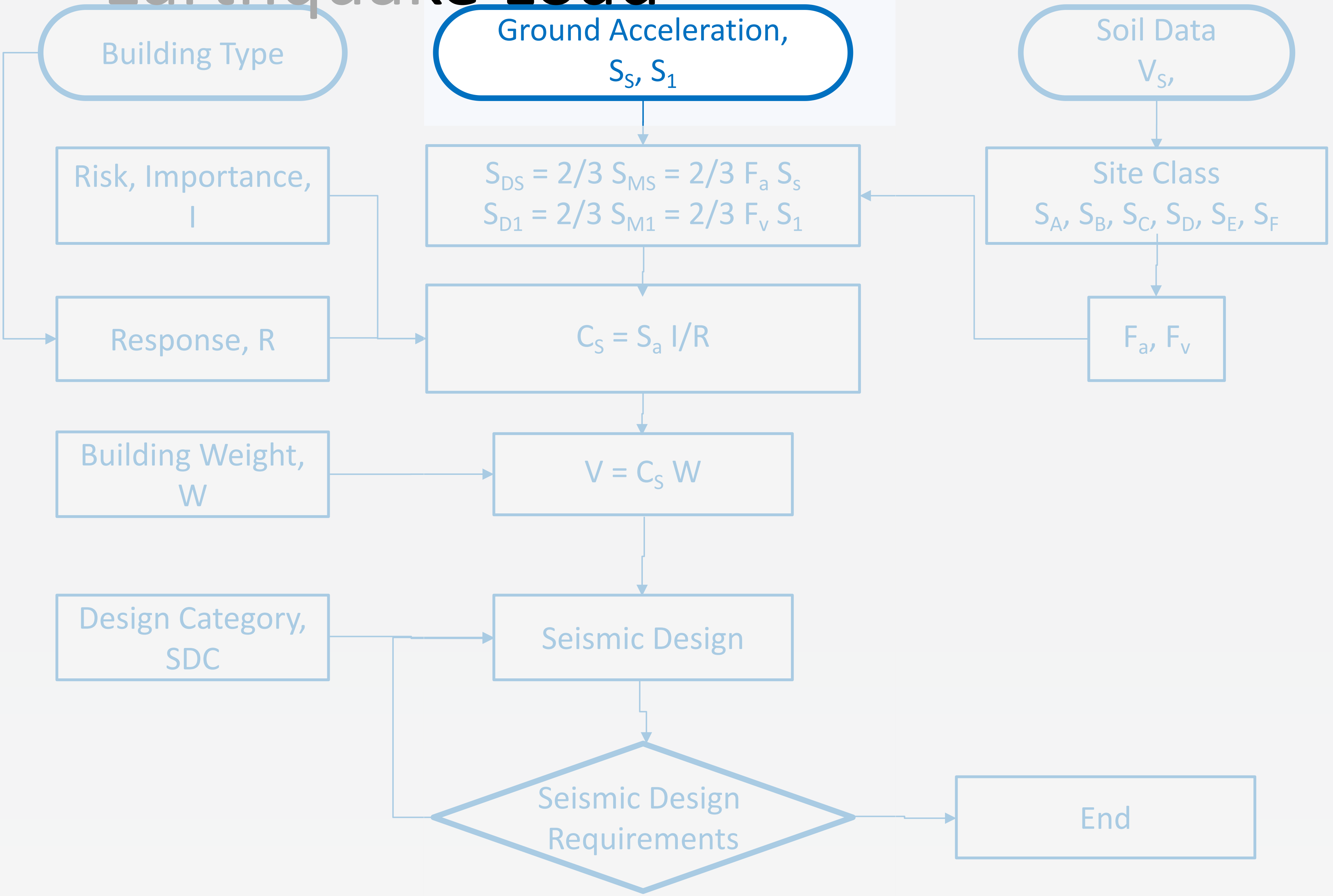
Earthquake Design Flow Chart



Ground Accelerations

Earthquake Load



Ground Accelerations

- **Ground Acceleration, S_S, S_1**

Building Type

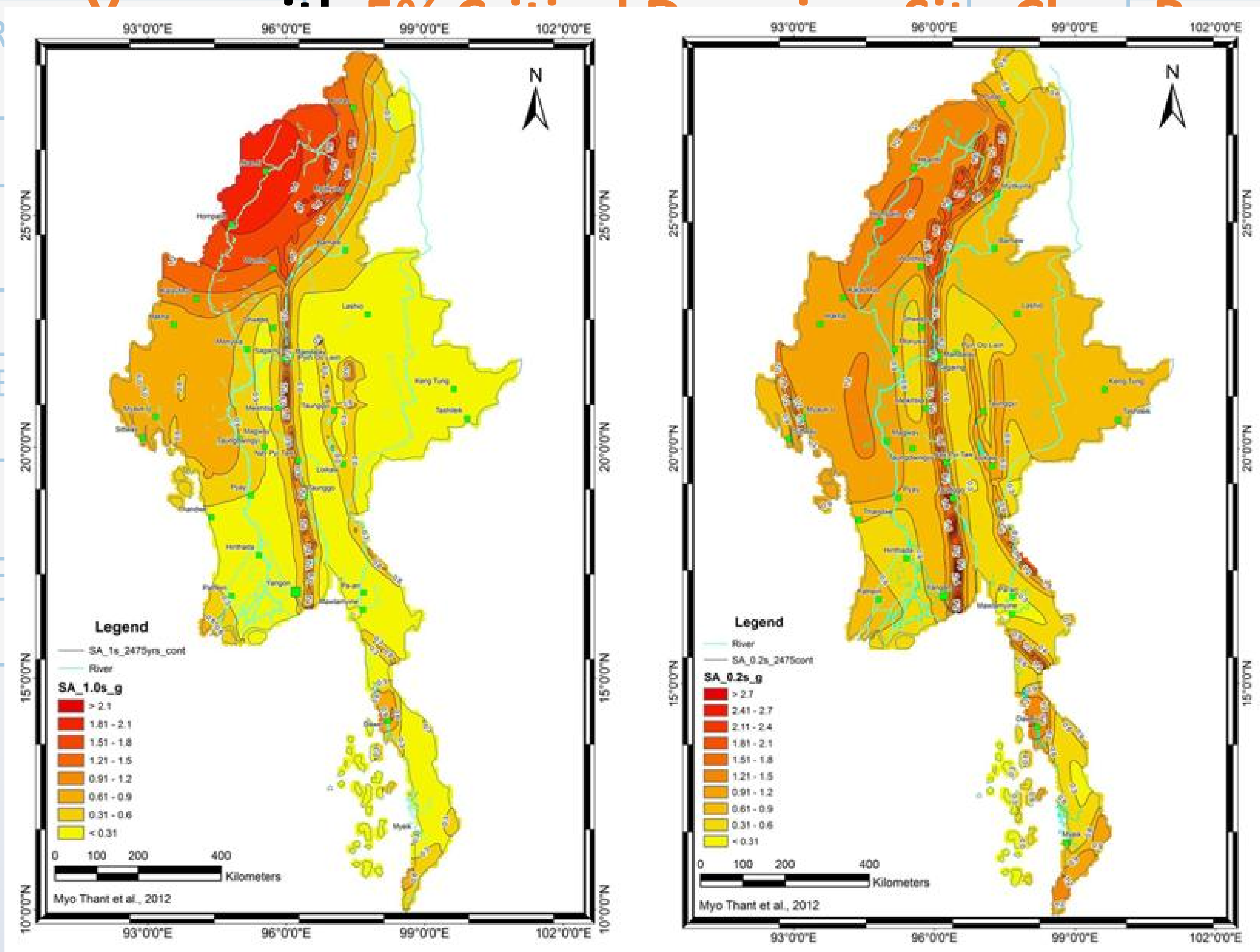
Ground Acceleration, S_S, S_1

Soil Data V_s

- **Spectral Response Acceleration at 2% Probability in 50 Years with 5% Critical Damping, Site Class B**

Site Class

S_C, S_D, S_E, S_F



S_s for 0.2 second

Short Period Acceleration

for Short Buildings

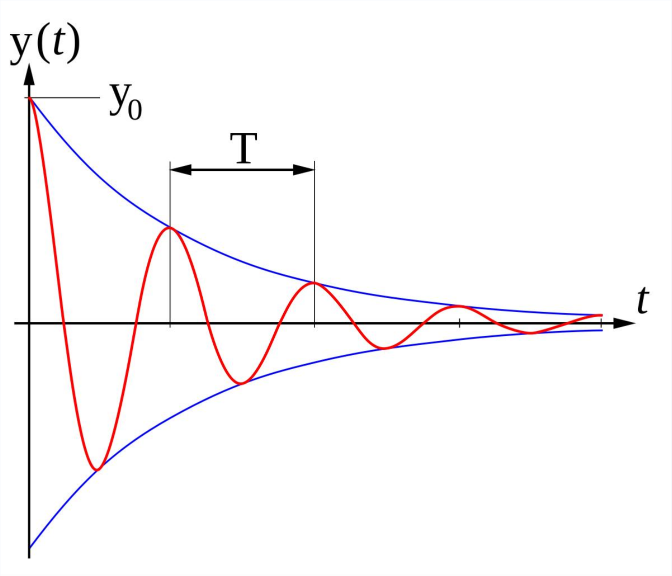
S_1 for 1 second

Long Period Acceleration

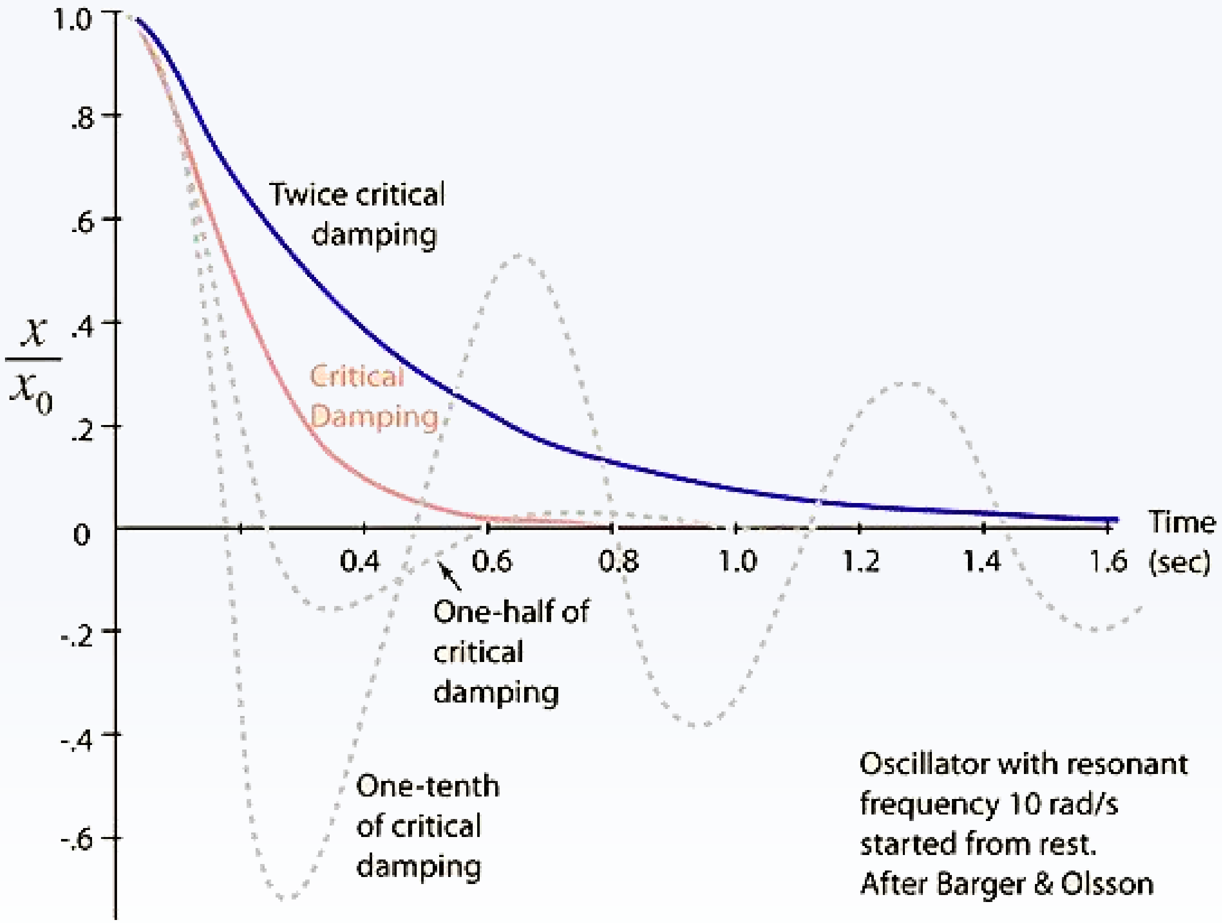
for Tall Buildings

Ground Accelerations

Spectral Response Acceleration at 2% Probability in 50 Years with **5% Critical Damping**, Site Class B



- For buildings,
- oscillation decays at
- 5% critical damping.



Ground Accelerations

- **Site Class**

SITE CLASS	SOIL PROFILE NAME	AVERAGE PROPERTIES IN TOP 100 feet		
		Shear wave velocity, v_S , (ft/s)	SPT, N	Undrained shear, s_u , (psf)
A	Hard rock	v s > 5,000	N/A	N/A
B	**Rock**	**2,500 > v_s > 5,000**	**N/A**	**N/A**
C	Very dense soil and soft rock	1,200 ≤ v_s ≤ 2,500	N > 50	s_u ≤ 2,000
D	Stiff soil profile	600 ≤ v_s ≤ 1,200	15 ≤ N ≤ 50	1,000 ≤ s_u ≤ 2,000
E	Soft soil profile	v s < 600	N < 15	s_u < 1,000
F	Very soft / Unknown	Need further investigation.		

Soil Factors

Earthquake Load

Building Type

Ground Acceleration, S_S, S_1

Soil Data V_S,

Risk, Importance, I

$S_{DS} = 2/3\ S_{MS} = 2/3\ F_a\ S_s$

$S_{D1} = 2/3\ S_{M1} = 2/3\ F_v\ S_1$

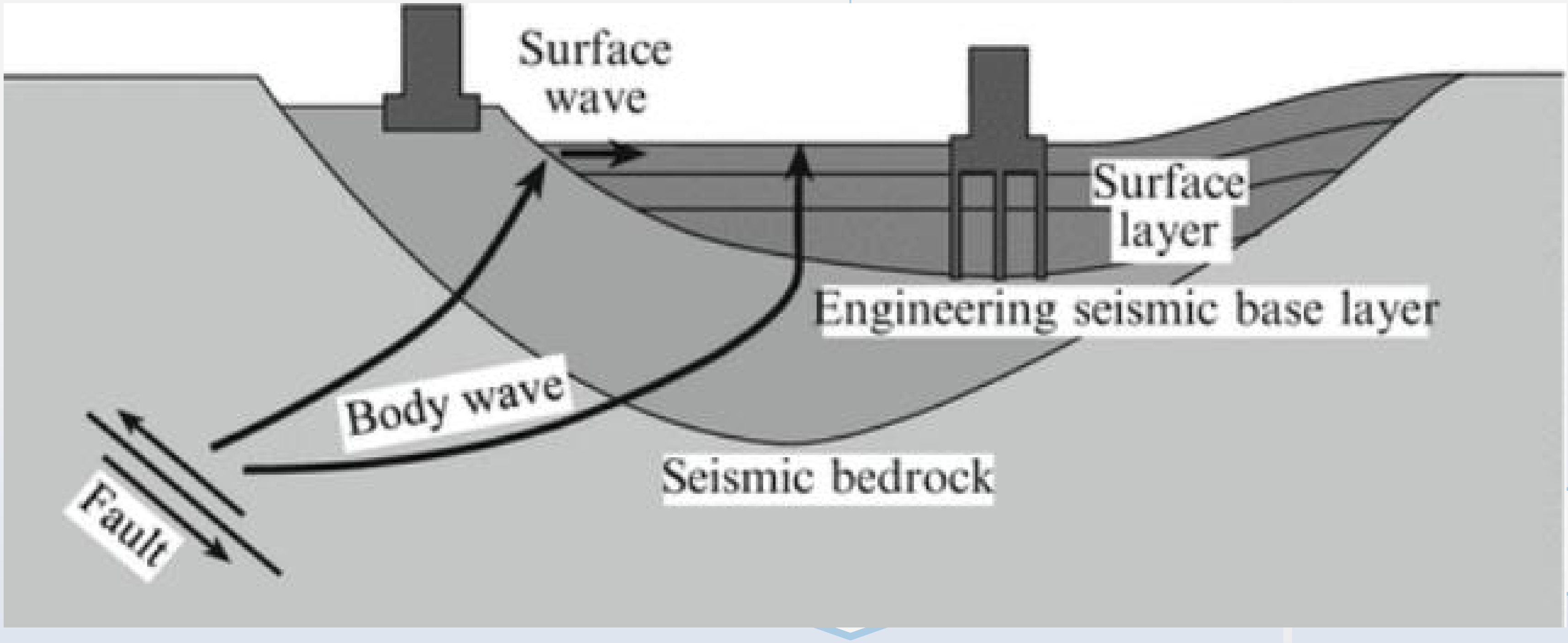
Site Class

S_A, S_B, S_C, S_D, S_E, S_F

Response, R

$C_S = S_a\ I/R$

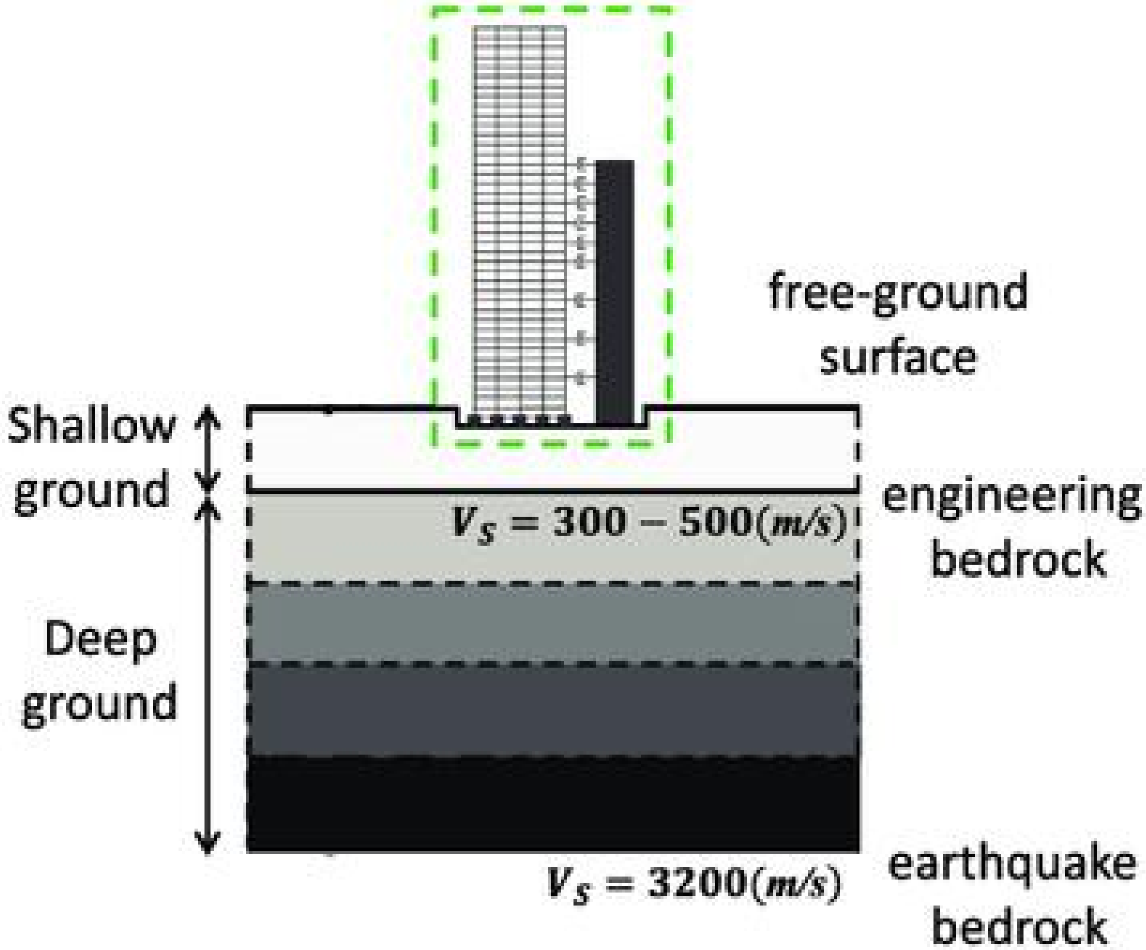
F_a, F_v



Soil Factors

Site Class

Spectral Response Acceleration at 2% Probability in 50 Years with 5% Critical Damping, **Site Class B**



Soil Factors

Site Coefficients F_a, F_v

Site Coefficients F_a, F_v

Fa: Site modification fact

for short period,

Short Buildings

Fa: Site modification factor for short period,

Short Buildings

TABLE 3.4.3 SITE COEFFICIENT, F_a

Site Class	Mapped Maximum Considered Earthquake Spectral Response Acceleration Parameter at Short Period				
	$S_S \le 0.25$	$S_S = 0.5$	$S_S = 0.75$	$S_S = 1.0$	$S_S \ge 1.25$
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	See Section 11.3.4.7				

NOTE: Use straight-line interpolation for intermediate values of S_s.

Fv: Site modification factor for long period,

Tall Buildings

Fv: Site modification fact

for long period,

Tall Buildings

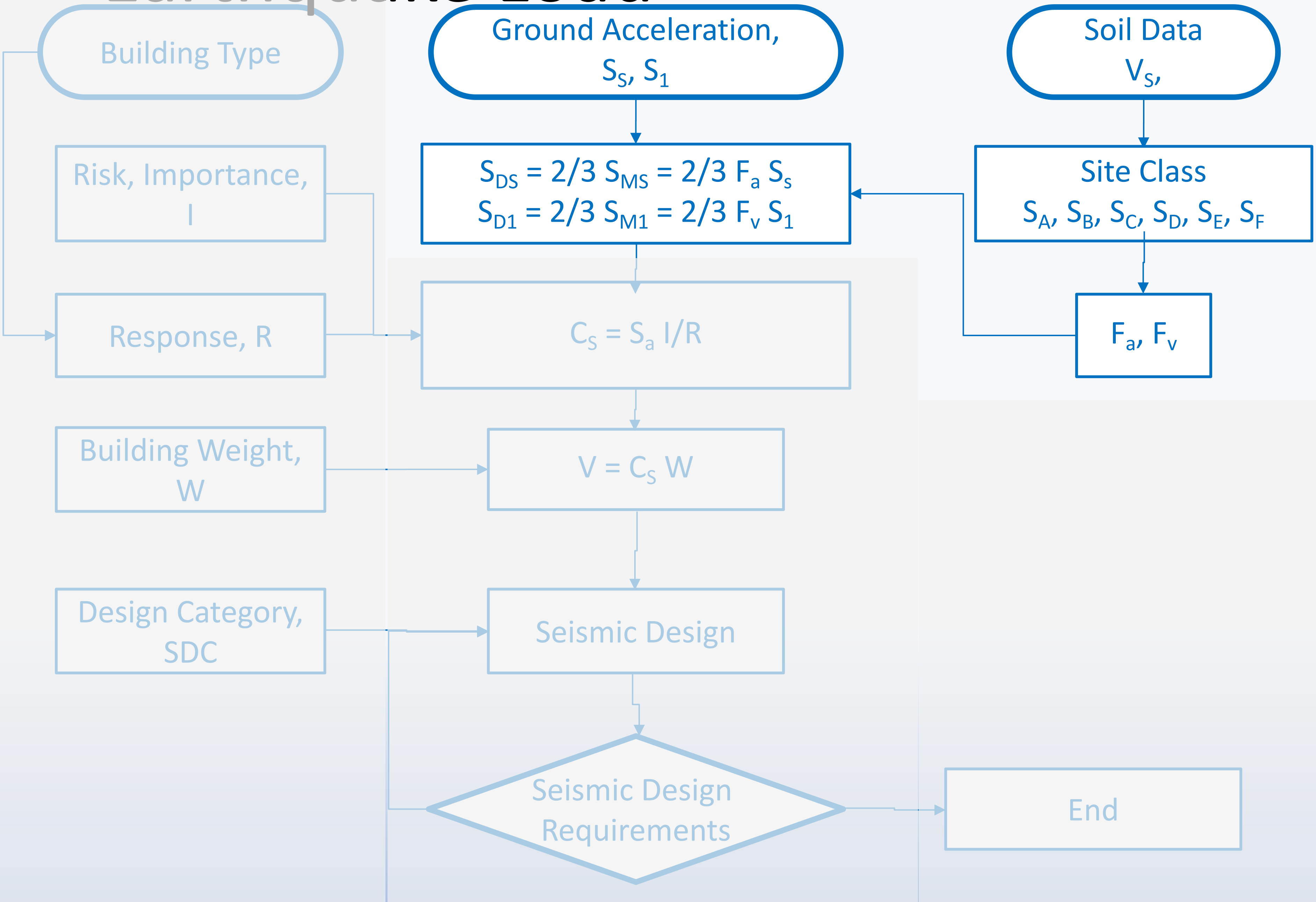
TABLE 3.4.4 SITE COEFFICIENT, F_v

Site Class	Mapped Maximum Considered Earthquake Spectral Response Acceleration Parameter at 1-s Period				
	$S_1 \le 0.1$	$S_1 = 0.2$	$S_1 = 0.3$	$S_1 = 0.4$	$S_1 \ge 0.5$
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	See Section 11.3.4.7				

NOTE : *Use straight-line interpolation for intermediate values of S_1.*

Design Acceleration, MCE to DBE

Earthquake Load



Design Acceleration, MCE to DBE

- Design Spectral Acceleration, S_{DS}

  - SDS = 2/3 Fa Ss

  - $S_{D1} = 2/3\ F_v\ S_1$

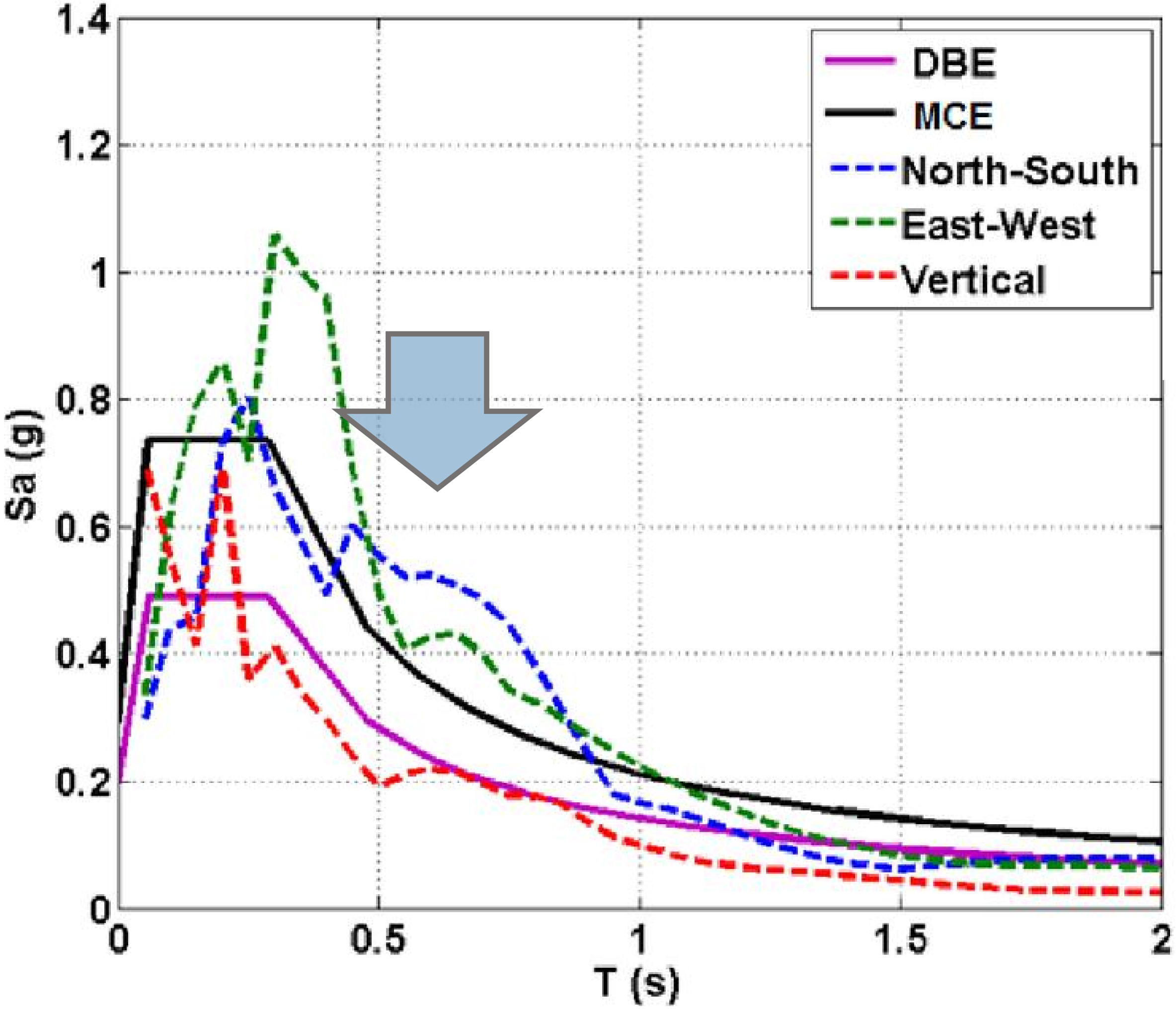
MCE: Maximum Considered Earthquake

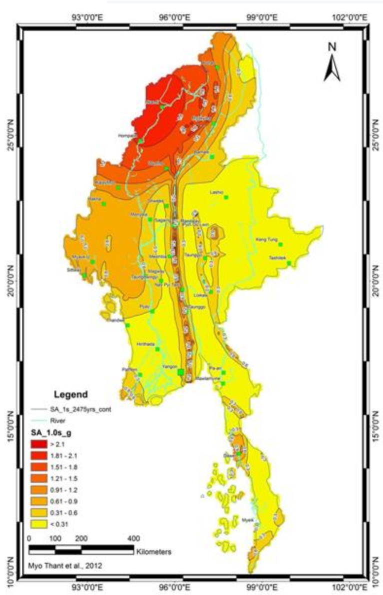
(2% probability in 50 years)

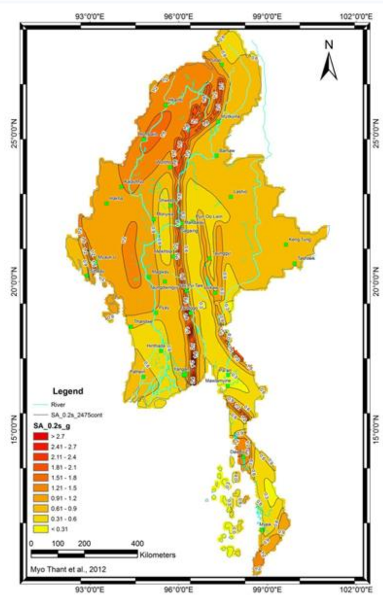
DBE: Design Basis Earthquake

(10% probability in 50 years)

Reduce MCE to DBE by 2/3

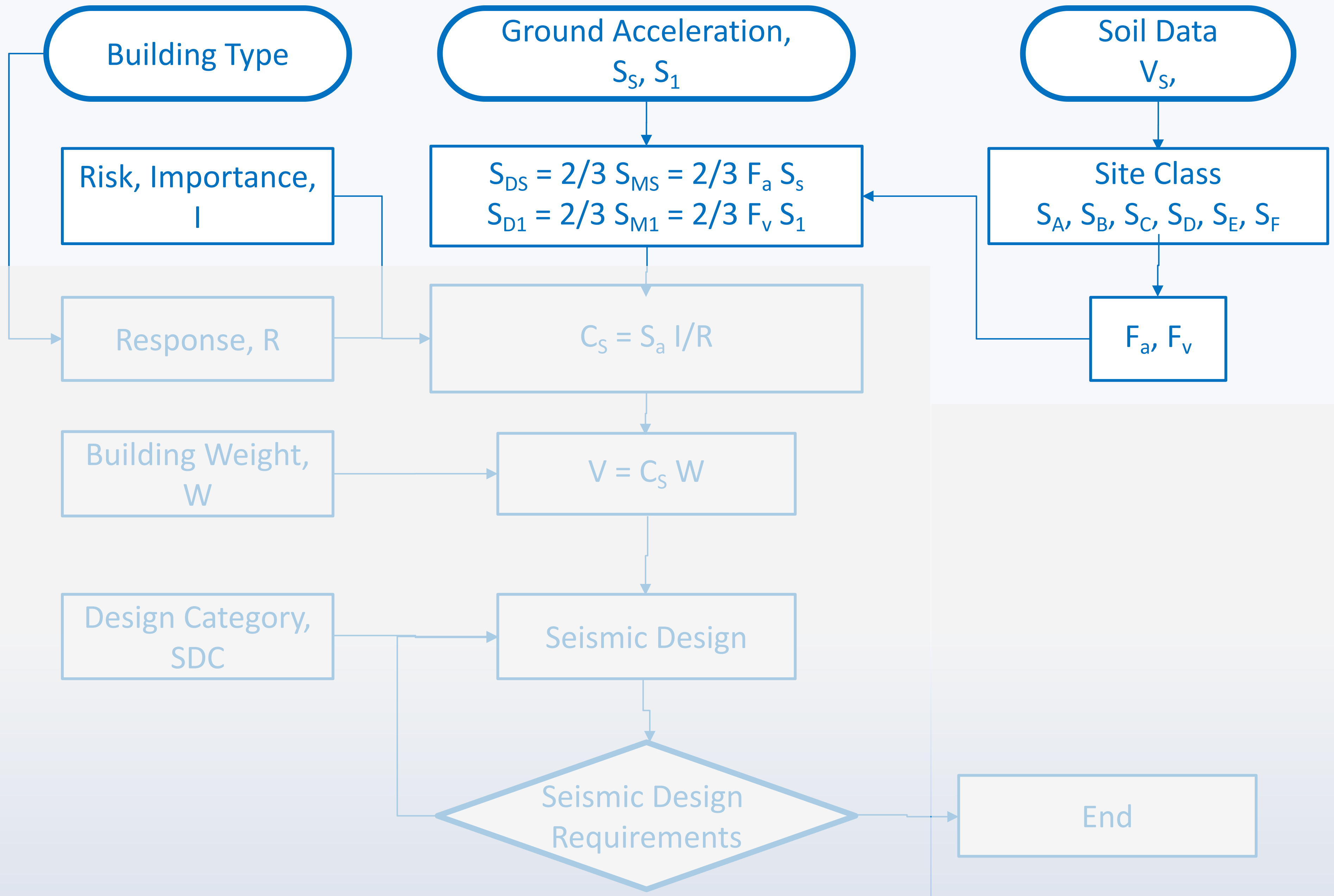






Earthquake Load

Importance (Risk) Factor



Importance (Risk) Factor

- Importance Factor, I

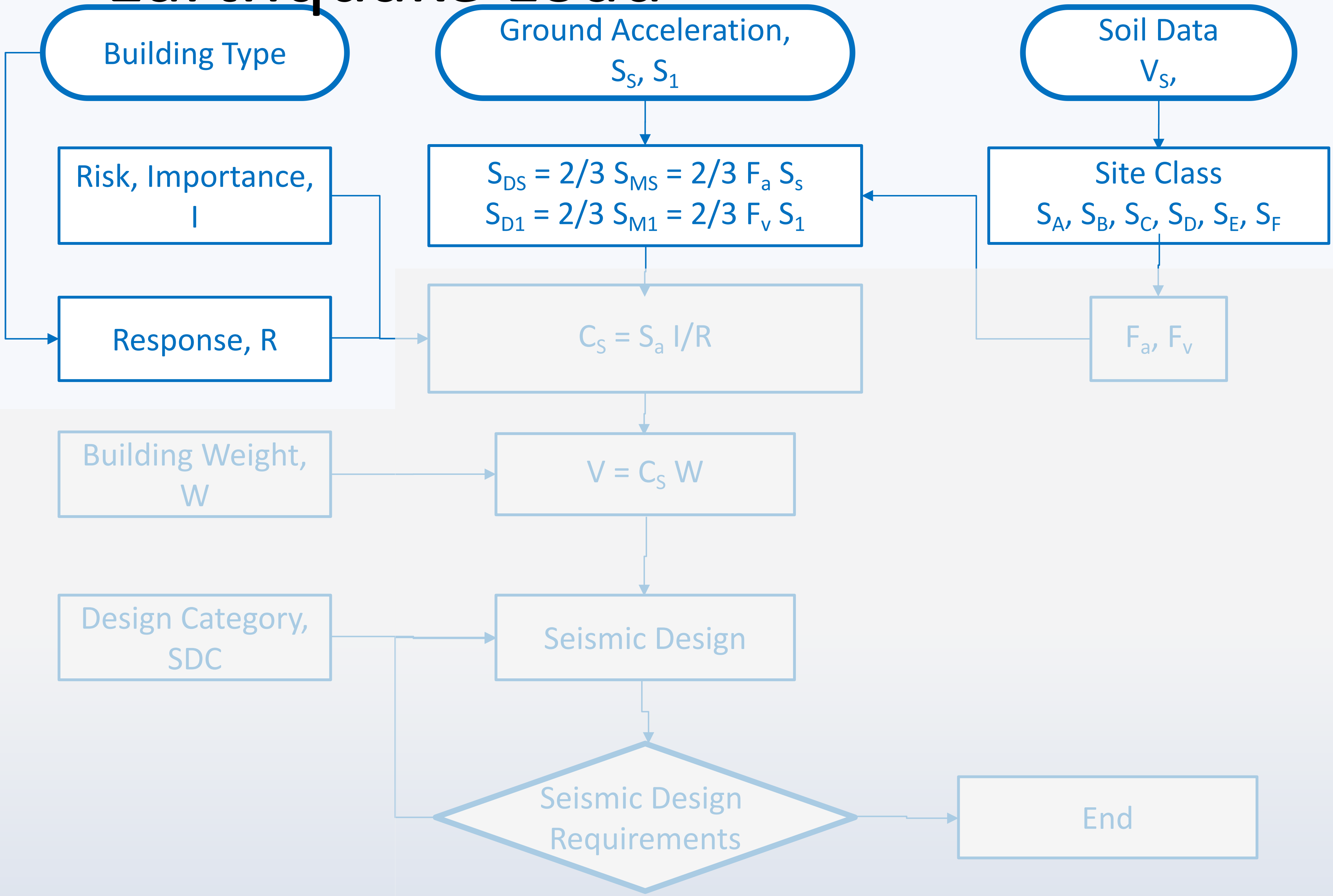
Risk Category	Nature of Occupancy
I	Representing a low hazard to human life in the event of failure
II	Except those listed in other categories
III	Represent a substantial hazard to human life in the event of failure
IV	Designed as essential facilities

TABLE 3.4.6 IMPORTANCE FACTORS

Occupancy Category	*I*
I or II	1.0
III	1.25
IV	1.5

Response (Ductility) Factors

Earthquake Load



Response (Ductility) Factors

Response Factors: R, C_d, Ω_0

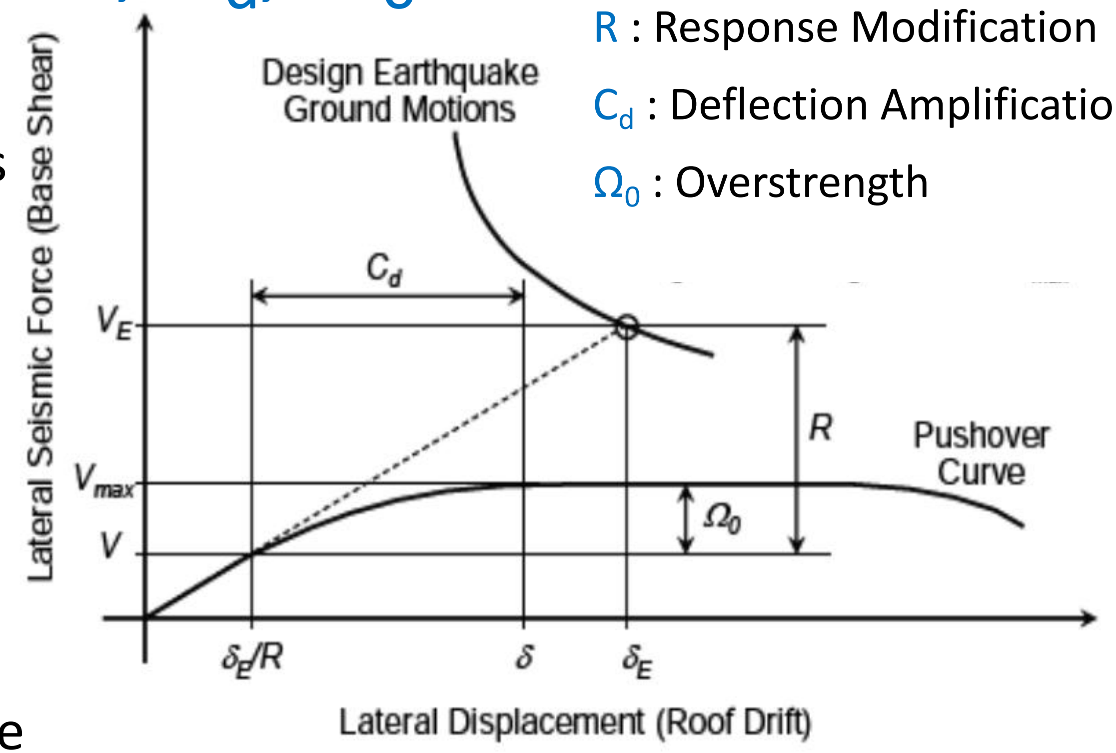
R : Response Modification

C_d : Deflection Amplification

Ω_0 : Overstrength

Seismic Force Resisting Systems

- A Bearing Wall Systems
- B Building Frame Systems
- C Moment Resisting Frame Systems
- D Dual Systems with SMRS
- E Dual Systems with IMRS
- F Shear Wall – Frame Interactive Systems
- G Cantilever Column Systems
- H Steel Systems



Seismic Force-Resisting System	ASCE 7-05, Required Detailing	Response Modification Factor, R[a]	System Over strength Factor, Ω_0[g]	Deflection Amplification Factor, C_d[b]	Structural System Limitations and Building Height (ft) Limit[c]				
					Seismic Design Category				
					B	C	D[d]	E[d]	F[e]
A. BEARING WALL SYSTEMS									
1.Special reinforced concrete shear walls	14.2	5	2½	5	NL	NL	160	160	100
2.Ordinary reinforced concrete shear walls	14.2	4	2½	4	NL	NL	NP	NP	NP
3. Detailed plain concrete shear walls	14.2	2	2½	2	NL	NP	NP	NP	NP
4. Ordinary plain concrete shear walls	14.2	1½	2½	1½	NL	NP	NP	NP	NP
5.Intermediate precast shear walls	14.2	4	2½	4	NL	NL	40[k]	40[k]	40[k]
6. Ordinary precast shear walls	14.2	3	2½	3	NL	NP	NP	NP	NP
7. Special reinforced masonry shear walls	14.4	5	2½	3½	NL	NL	160	160	100
8. Intermediate reinforced masonry shear walls	14.4	3½	2½	2¼	NL	NL	NP	NP	NP
9. Ordinary reinforced masonry shear walls	14.4	2	2½	1¾	NL	160	NP	NP	NP
10. Detailed plain masonry shear walls	14.4	2	2½	1¾	NL	NP	NP	NP	NP

Response (Ductility) Factors

Response Factors: R, C_d, Ω_0

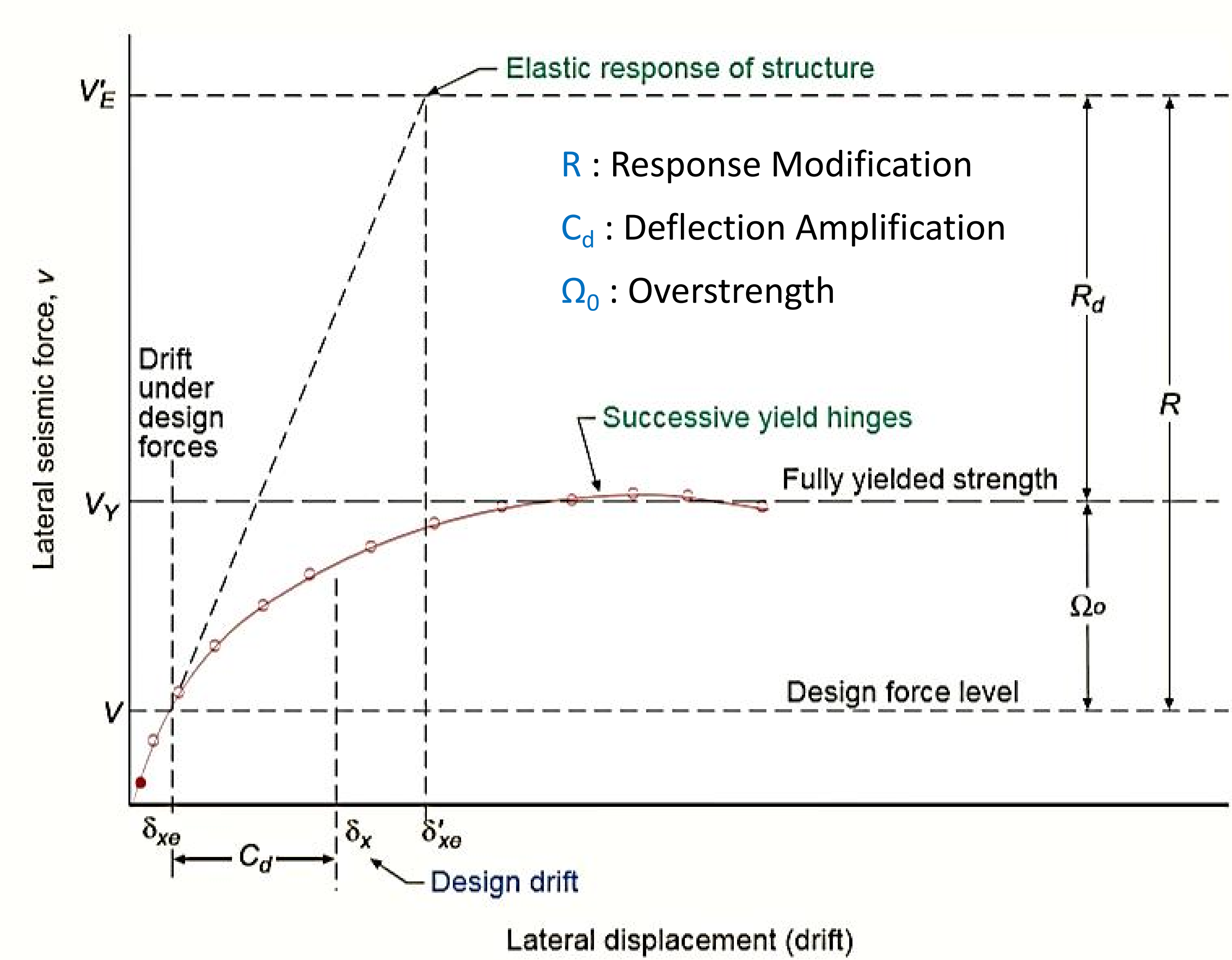
Seismic Force Resisting Systems

- A Bearing Wall Systems
- B Building Frame Systems
- C Moment Resisting Frame Systems
- D Dual Systems with SMRS
- E Dual Systems with IMRS
- F Shear Wall – Frame Interactive Systems
- G Cantilever Column Systems
- H Steel Systems

Table 16-21. Earthquake force-resisting structural systems of concrete – ASCE 7-05

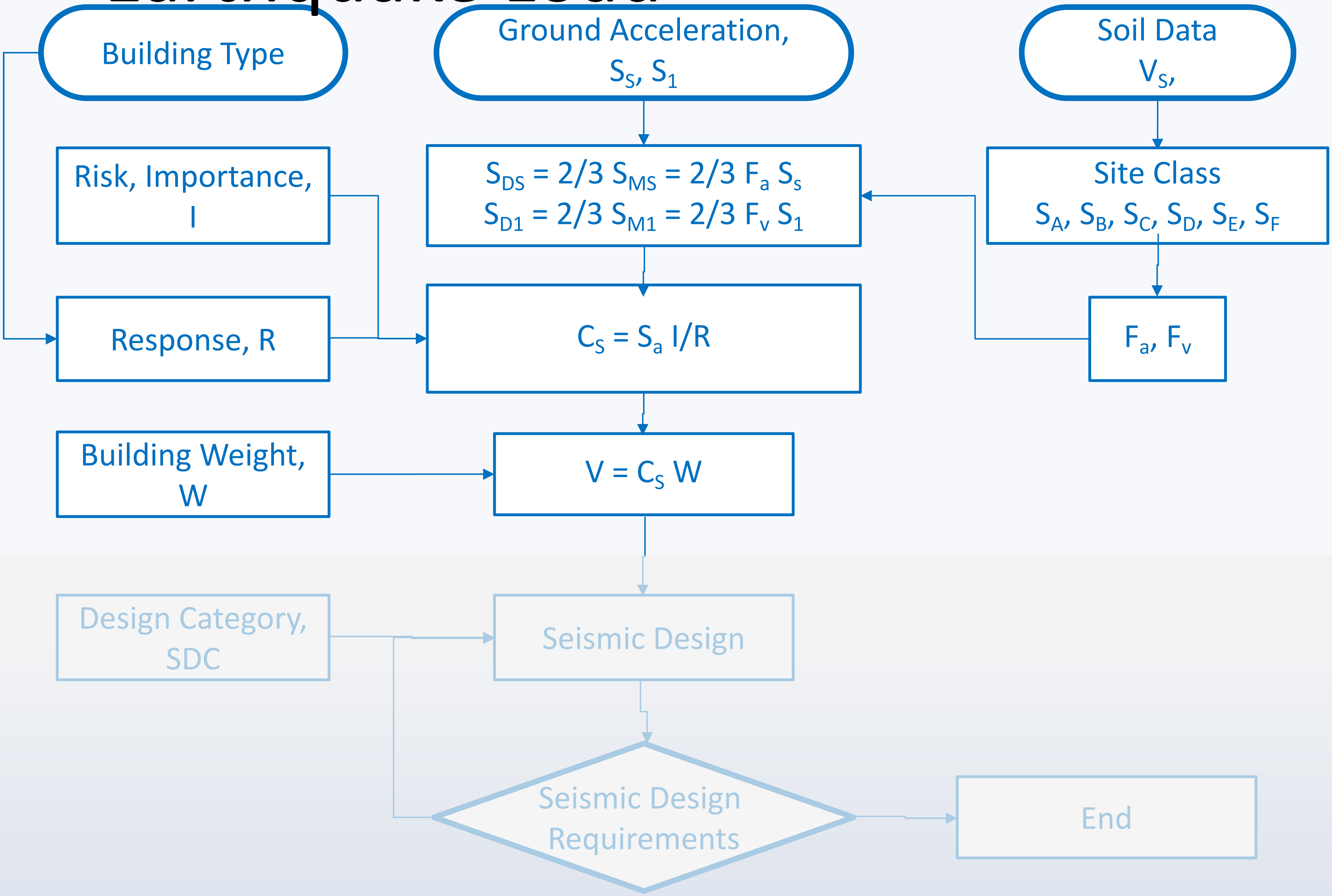
Basic Seismic-force Resisting System	Detailing Ref. Section	R	Ω_0	C_d	System Limitations and Building Height Limitations (ft) by Seismic Design Category				
					B	C	D	E	F
Bearing Wall Systems									
Special reinforced concrete shear walls	14.2 and 14.2.3.6	5	2½	5	NL	NL	160	160	100
Ordinary reinforced concrete shear walls	14.2 and 14.2.3.4	4	2½	4	NL	NL	NP	NP	NP
Detailed plain concrete shear walls	14.2 and 14.2.3.2	2	2½	2	NL	NP	NP	NP	NP
Ordinary plain concrete shear walls	14.2 and 14.2.3.1	1½	2½	1½	NL	NP	NP	NP	NP
Intermediate precast shear walls	14.2 and 14.2.3.5	4	2½	4	NL	NL	40[1]	40[1]	40[1]
Ordinary precast shear walls	14.2 and 14.2.3.3	3	2½	3	NL	NP	NP	NP	NP
Building Frame Systems									
Special reinforced concrete shear walls	14.2 and 14.2.3.6	6	2½	5	NL	NL	160	160	100
Ordinary reinforced concrete shear walls	14.2 and 14.2.3.4	5	2½	4½	NL	NL	NP	NP	NP
Detailed plain concrete shear walls	14.2 and 14.2.3.2	2	2½	2	NL	NP	NP	NP	NP
Ordinary plain concrete shear walls	14.2 and 14.2.3.1	1½	2½	1½	NL	NP	NP	NP	NP
Intermediate precast shear walls	14.2 and 14.2.3.5	5	2½	4½	NL	NL	40[1]	40[1]	40[1]
Ordinary precast shear walls	14.2 and 14.2.3.3	4	2½	4	NL	NP	NP	NP	NP
Moment-resisting Frame Systems									
Special reinforced concrete moment frames	12.2.5.5 and 14.2	8	3	5½	NL	NL	NL	NL	NL
Intermediate reinforced concrete moment frames	14.2	5	3	4½	NL	NL	NP	NP	NP
Ordinary reinforced concrete moment frames	14.2	3	3	2½	NL	NP	NP	NP	NP
Dual Systems with Special Moment Frames									
Special reinforced concrete shear walls	14.2	7	2½	5½	NL	NL	NL	NL	NL
Ordinary reinforced concrete shear walls	14.2	6	2½	5	NL	NP	NP	NP	NP
Dual Systems with Intermediate Moment Frames									
Special reinforced concrete shear walls	14.2	6½	2½	5	NL	NL	160	100	100
Ordinary reinforced concrete shear walls	14.2	5½	2½	4½	NL	NL	NP	NP	NP
Shear Wall-frame Interactive System with Ordinary Reinforced Concrete Moment Frames and Ordinary Reinforced Concrete Shear Walls	12.2.5.10 and 14.2	4½	2½	4	NL	NP	NP	NP	NP

Response (Ductility) Factors



Seismic Coefficient, Cs

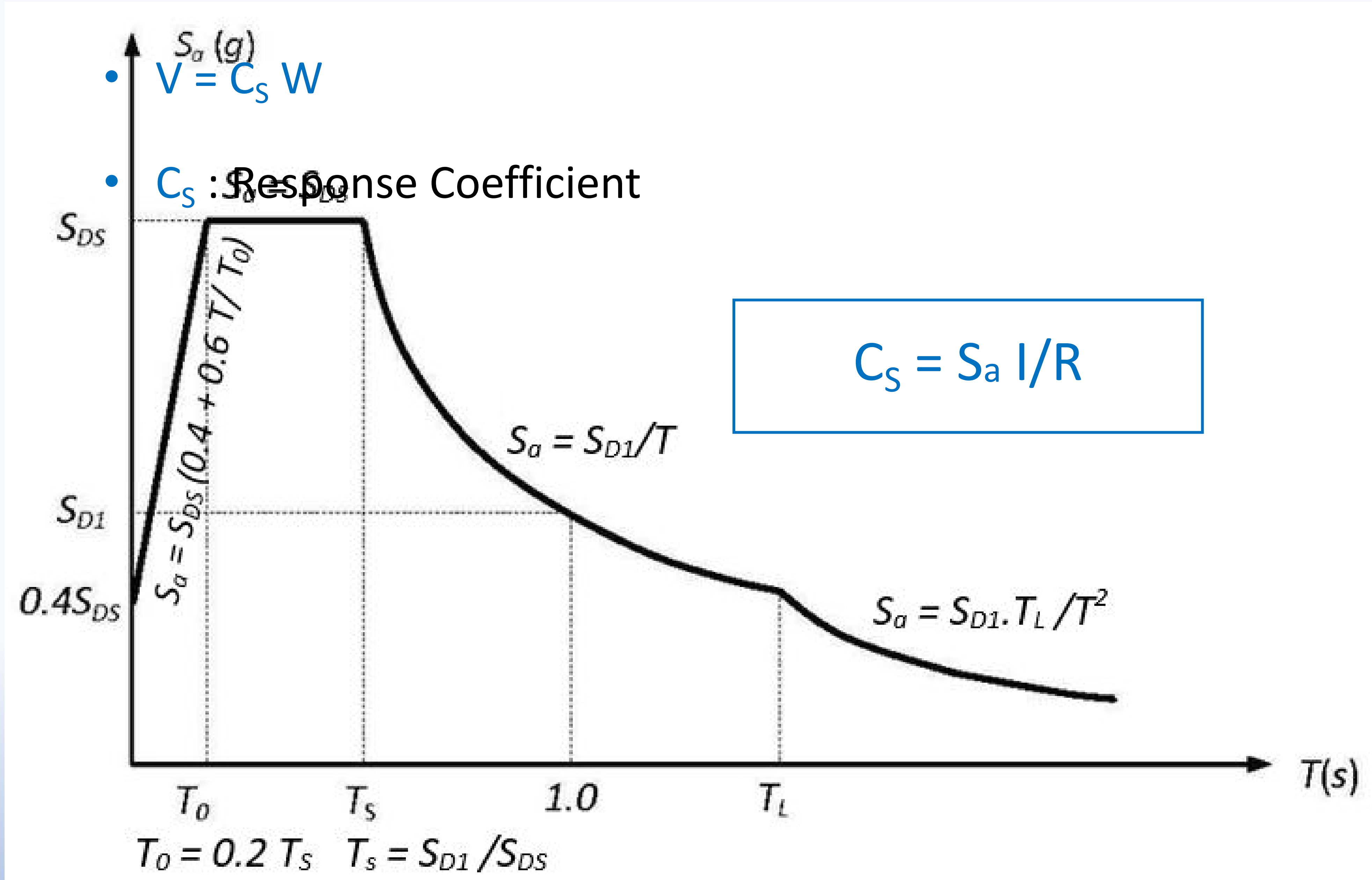
Earthquake Load



Seismic Coefficient, C_s

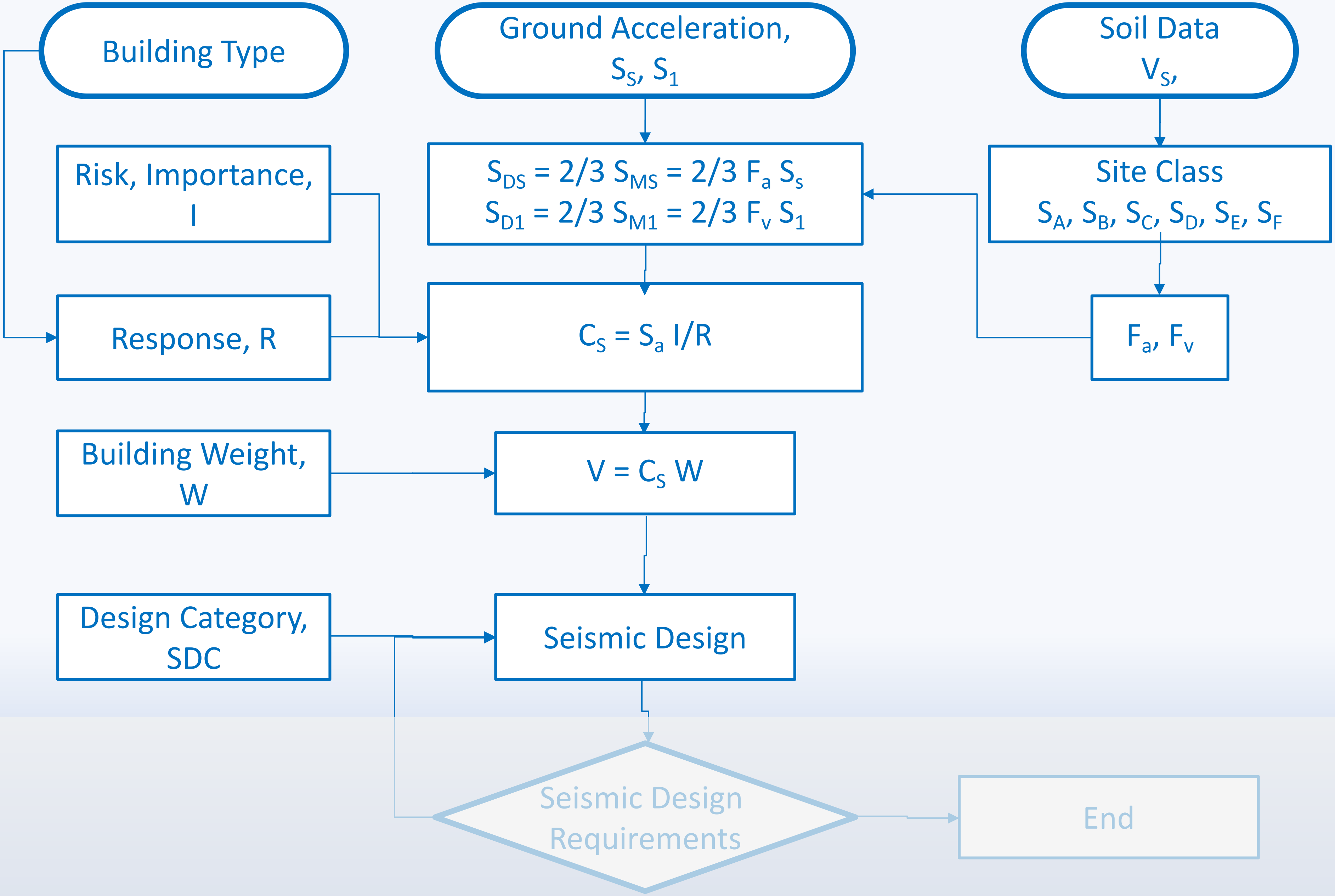
- Seismic Base Shear: V
- $V = C_S W$
- C_S : Response Coefficient

$$C_S = S_a I/R$$



Earthquake Load

Seismic Design Category, SDC



Seismic Design Category, SDC

Seismic Design C

There are various correlations of the qualitative Modified Mercalli Intensity (MMI) with quantitative characterizations of ground-shaking limits for the various SDCs.

MMI V	No real damage	SDC A	$0 < S_{M1} < 0.1g$
MMI VI	Light nonstructural damage	SDC B	$0.1g < S_{M1} < 0.2g$
MMI VII	Hazardous nonstructural damage	SDC C	$0.2g < S_{M1} < 0.3g$
MMI VIII	Hazardous damage to susceptible structures	SDC D	$0.3 < S_{M1} < 1.12g$
MMI IX	Hazardous damage to robust structures	SDC E	$S_{M1} > 1.125g$

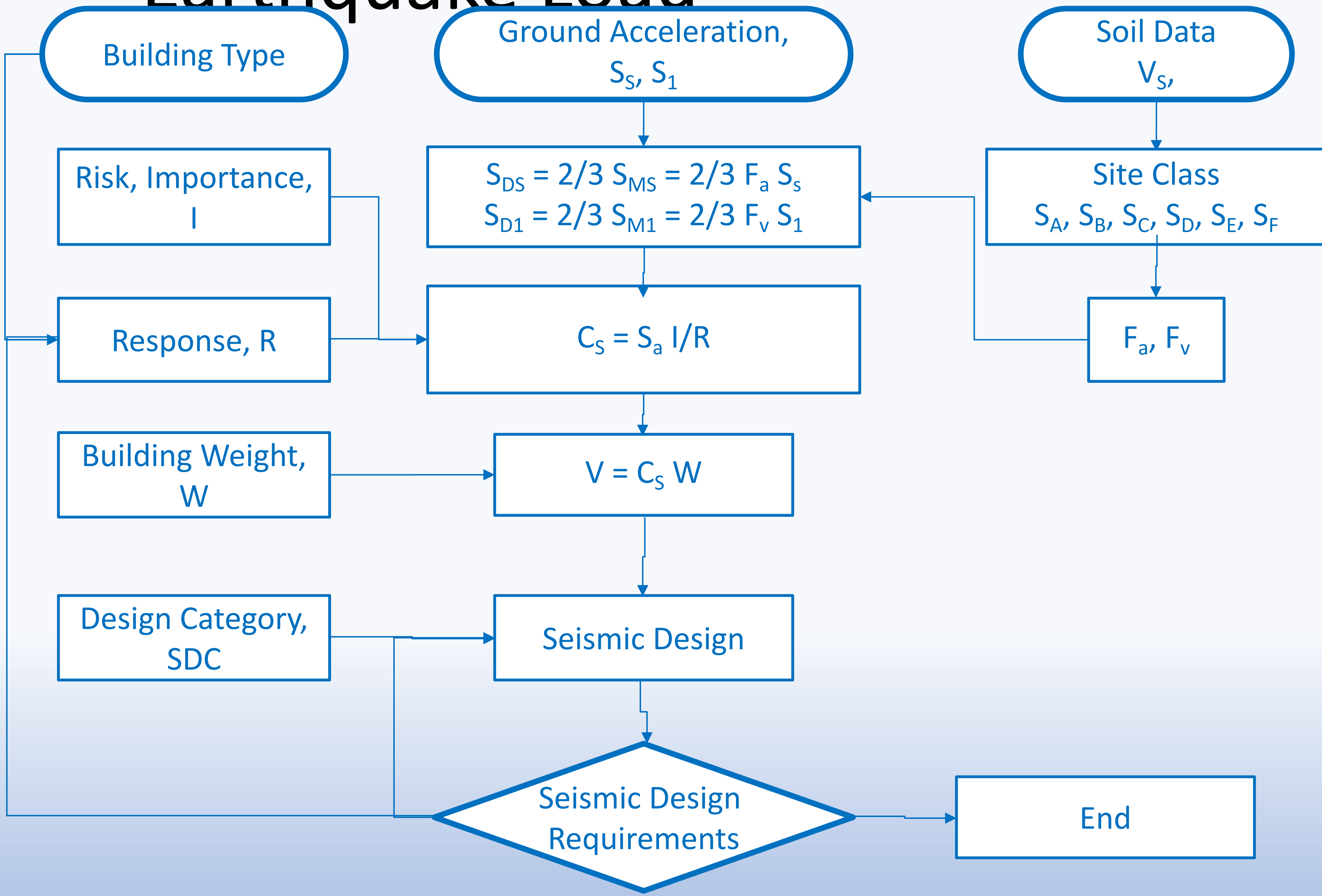
Occupancy

Risk Category	Nature of Occupancy
I	Representing a low hazard to human life in the event of failure
II	Except those listed in other categories
III	Represent a substantial hazard to human life in the event of failure
IV	Designed as essential facilities

S_{DS}`	S_{D1}	Level of Seismicity	I & II	III	IV
<0.167 g	<0.067 g	Very Low	**A**	**A**	**A**
0.167 to 0.33 g	0.067 to 0.133 g	Low	**A**	**B**	**C**
0.33 to 0.5 g	0.133 to 0.2 g	Moderate	**B**	**C**	**D**
>0.5 g	>0.2 g	High	**C**	**D**	**D**

Seismic Design Requirements

Earthquake Load



Seismic Design Requirements

Table 6.6.3.1.1(a)—Moment of inertia and cross-sectional area permitted for elastic analysis at factored load level

Member and condition		Moment of Inertia	Cross-sectional area
Columns		$0.70I_g$	$1.0A_g$
Walls	Uncracked	$0.70I_g$	
	Cracked	$0.35I_g$	
Beams		$0.35I_g$	
Flat plates and flat slabs		$0.25I_g$	

Seismic Design Requirements

TABLE 12.6-1 PERMITTED ANALYTICAL PROCEDURES

Seismic Design Category	Structural Characteristics	Equivalent Lateral Force Analysis Section 12.8	Modal Response Spectrum Analysis Section 12.9	Seismic Response History Procedures Chapter 16
B, C	Occupancy Category I or II buildings of light-framed construction not exceeding 3 stories in height	P	P	P
	Other Occupancy Category I or II buildings not exceeding 2 stories in height	P	P	P
	All other structures	P	P	P
D, E, F	Occupancy Category I or II buildings of light-framed construction not exceeding 3 stories in height	P	P	P
	Other Occupancy Category I or II buildings not exceeding 2 stories in height	P	P	P
	Regular structures with $T < 3.5T_s$ and all structures of light frame construction	P	P	P
	Irregular structures with $T < 3.5T_s$ and having only horizontal irregularities Type 2, 3, 4, or 5 of Table 12.2-1 or vertical irregularities Type 4, 5a, or 5b of Table 12.3-1	P	P	P
	All other structures	NP	P	P

Seismic Design Requirements

SDC	Building Type and Expected MMI	Seismic Criteria
A	Buildings located in regions having a very small probability of experiencing damaging earthquake effects	No specific seismic design requirements but structures are required to have complete lateral-force-resisting systems and to meet basic structural integrity criteria.
B	Structures of ordinary occupancy that could experience moderate (MMI VI) intensity shaking	Structures must be designed to resist seismic forces.
C	Structures of ordinary occupancy that could experience strong (MMI VII) and important structures that could experience moderate (MMI VI) shaking	Structures must be designed to resist seismic forces. Critical nonstructural components must be provided with seismic restraint.
D	Structures of ordinary occupancy that could experience very strong shaking (MMI VIII) and important structures that could experience MMI VII shaking	Structures must be designed to resist seismic forces. Only structural systems capable of providing good performance are permitted. Nonstructural components that could cause injury must be provided with seismic restraint. Nonstructural systems required for life safety protection must be demonstrated to be capable of post-earthquake functionality. Special construction quality assurance measures are required.

Seismic Design Requirements

SDC	Building Type and Expected MMI	Seismic Criteria
E	Structures of ordinary occupancy located within a few kilometers of major active faults capable of producing MMI IX or more intense shaking	Structures must be designed to resist seismic forces. Only structural systems that are capable of providing superior performance permitted. Many types of irregularities are prohibited. Nonstructural components that could cause injury must be provided with seismic restraint. Nonstructural systems required for life safety protection must be demonstrated to be capable of post-earthquake functionality. Special construction quality assurance measures are required.
F	Critically important structures located within a few kilometers of major active faults capable of producing MMI IX or more intense shaking	Structures must be designed to resist seismic forces. Only structural systems capable of providing superior performance permitted are permitted. Many types of irregularities are prohibited. Nonstructural components that could cause injury must be provided with seismic restraint. Nonstructural systems required for facility function must be demonstrated to be capable of post-earthquake functionality. Special construction quality assurance measures are required.

Seismic Design Requirements

Item	Type	Description	SDC B	SDC C	SDC D	SDC E	SDC F	Issue	Reference
H1a	Torsional Irregularity	The maximum storey drift, computed including accidental torsion, at one end of the structure transverse to an axis is more than 1.2 times the average of the storey drifts at the two ends of the structure. Torsional irregularity requirements in the reference sections apply only to structures in which the diaphragms are rigid or semirigid.			√	√	√	Force Increase	3.4.3.3.4
					√	√	√	Analysis Limit	3.4.6, Table 3.4.12
			√	√	√	√	√	3D Model	3.4.7.3, ASCE7-05 16.2.2
				√	√	√	√	Torsion Limit	3.4.8.4.3
				√	√	√	√	Drift Limit	3.4.12.1
H1b	Extreme Torsional Irregularity	The maximum storey drift, computed including accidental torsion, at one end of the structure transverse to an axis is more than 1.4 times the average of the storey drifts at the two ends of the structure. Extreme torsional irregularity requirements in the reference sections apply only to structures in which the diaphragms are rigid or semirigid.						Not Permit	3.4.3.3.1
					√			Force Increase	3.4.3.3.4
					√			Analysis Limit	3.4.6, Table 3.4.12
			√	√	√	X	X	3D Model	3.4.7.3, ASCE7-05 16.2.2
				√	√			Torsion Limit	3.4.8.4.3
				√	√			Drift Limit	3.4.12.1
H2	Reentrant Corner	Both plan projections of the structure beyond a reentrant corner are greater than 15% of the plan dimension of the structure in the given direction.			√	√	√	Force Increase	3.4.3.3.4
					√	√	√	Drift Limit	3.4.12.1
H3	Diaphragm Discontinuity	There are diaphragms with abrupt discontinuities or variations in stiffness, including those having cutout or open areas greater than 50% of the gross enclosed diaphragm area, or changes in effective diaphragm stiffness of more than 50% from one storey to the next.			√	√	√	Force Increase	3.4.3.3.4
					√	√	√	Drift Limit	3.4.12.1
H4	Out-of-Plane Offsets	There are discontinuities in a lateral force-resistance path, such as out-ofplane offsets of the vertical elements.	√	√	√	√	√	Redundancy	3.4.3.3.3
					√	√	√	Force Increase	3.4.3.3.4
					√	√	√	Analysis Limit	3.4.6, Table 3.4.12
			√	√	√	√	√	3D Model	3.4.7.3, ASCE7-05 16.2.2
H5	Nonparallel System	The vertical lateral force-resisting elements are not parallel to or symmetric about the major orthogonal axes of the seismic force–resisting system.		√	√	√	√	Directional	3.4.5.3
					√	√	√	Analysis Limit	3.4.6, Table 3.4.12
			√	√	√	√	√	3D Model	3.4.7.3, ASCE7-05 16.2.2

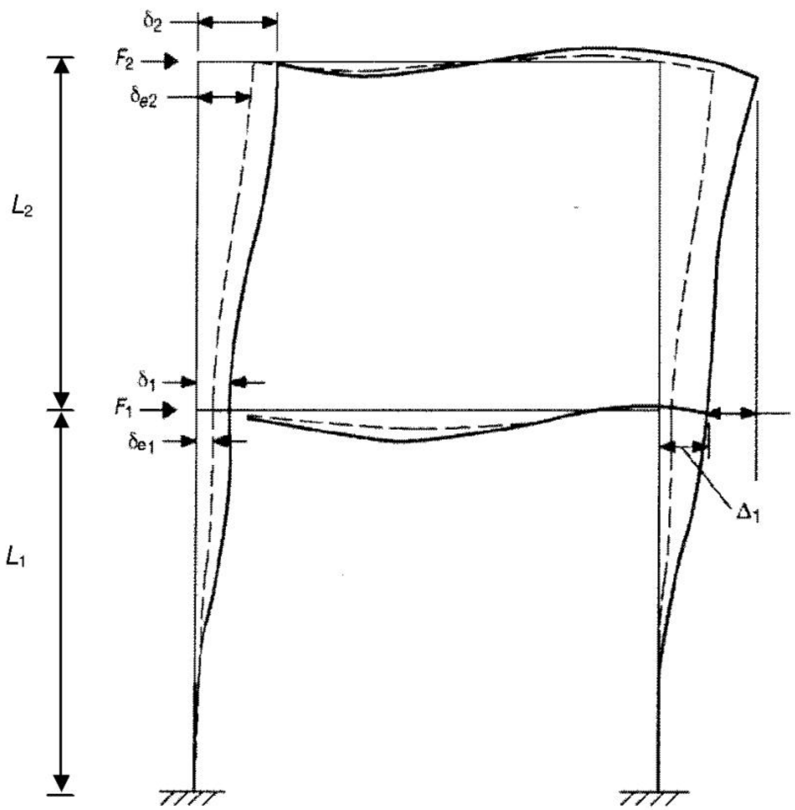
Seismic Design Requirements

Item	Type	Description	SDC					Issue	Reference
			B	C	D	E	F		
V1a	Soft Story (Stiffness)	A storey in which the lateral stiffness is less than 70% of that in the storey above or less than 80% of the average stiffness of the three storeys above.			√	√	√	Analysis Limit	3.4.6, Table 3.4.12
V1b	Extreme Soft Story (Stiffness)	A storey in which the lateral stiffness is less than 60% of that in the storey above or less than 70% of the average stiffness of the three storeys above.				X	X	Redundancy	3.4.3.3.3
					√	√	√	Analysis Limit	3.4.6, Table 3.4.12
V2	Weight Irregularity	The effective mass of any storey is more than 150% of the effective mass of an adjacent storey. A roof that is lighter than the floor below need not be considered.			√	√	√	Analysis Limit	3.4.6, Table 3.4.12
V3	Vertical Geometry	The horizontal dimension of the seismic force–resisting system in any storey is more than 130% of that in an adjacent storey.			√	√	√	Analysis Limit	3.4.6, Table 3.4.12
V4	In-plane Discontinuity	An in-plane offset of the lateral force-resisting elements is greater than the length of those elements or there exists a reduction in stiffness of the resisting element in the storey below.	√	√	√	√	√	Redundancy	3.4.3.3.3
						√	√	Force Increase	3.4.3.3.4
					√	√	√	Analysis Limit	3.4.6, Table 3.4.12
V5a	Weak Story (Strength)	The storey lateral strength is less than 80% of that in the storey above. The storey lateral strength is the total lateral strength of all seismic-resisting elements sharing the storey shear for the direction under consideration.				X	X	Not Permit	3.4.3.3.1
					√	√	√	Analysis Limit	3.4.6, Table 3.4.12
V5b	Extreme Weak Story (Strength)	The storey lateral strength is less than 65% of that in the storey above. The storey strength is the total strength of all seismic-resisting elements sharing the storey shear for the direction under consideration.						Not Permit	3.4.3.3.1
			√	√	X	X	X	Height Limit	3.4.3.3.2
								Analysis Limit	3.4.6, Table 3.4.12

Federation of Myanmar Engineering Societies

Seismic Design Requirements

Structure	Occupancy Category		
	I or II	III	IV
Structures, other than masonry shear wall structures, 4 storeys or less with interior walls, partitions, ceilings and exterior wall systems that have been designed to accommodate the storey drifts.	$0.025h_{sx}$ [c]	$0.020hsx$	$0.015hsx$
Masonry cantilever shear wall structures [d]	$0.010h_{sx}$	$0.010h_{sx}$	$0.010h_{sx}$
Other masonry shear wall structures	$0.007h_{sx}$	$0.007h_{sx}$	$0.007h_{sx}$
All other structures	$0.020h_{sx}$	$0.020h_{sx}$	$0.020h_{sx}$



Story Level 2

F_2 = strength-level design earthquake force

δ_{e2} = elastic displacement computed under strength-level design earthquake forces

δ_2 = $C_d\ \delta_{e2}/I_E$ = amplified displacement

Δ_2 = $(\delta_{e2} - \delta_{e1})\ C_d / I_E \le \Delta_a$ (Table 12.12-1)

Story Level 1

F_1 = strength-level design earthquake force

δ_{e1} = elastic displacement computed under strength-level design earthquake forces

δ_1 = $C_d\ \delta_{e1}/I_E$ = amplified displacement

Δ_1 = $\delta_1 \le \Delta_a$ (Table 12.12-1)

Δ_i = Story Drift

Δ_i/L_i = Story Drift Ratio

δ_2 = Total Displacement

MNBC 2020, Part 3, Structural Design Scope

$$Safety = \frac{Strength}{Hazard}$$

Code Based Design

Hazard, Load, Safety:
- MNBC 2020

- Strength, Capacity, Member Design:
  - Concrete: ACI
  - Steel: AISC
  - Masonry: Not Yet
  - Timber and Bamboo: Not Yet
  - Cold-form, Aluminum: Not Yet

Way Forward

- Adopted in 2020
- Needs
  - Corrections
  - Typo Errors
  - Inappropriate Translations
  - Modifications and Adjustments
- Prepare for next update, 2025?
-
-
-
- Thank you.