RC 2018 XVII Reunión del CONCRETO

El evento del Cemento, el Concreto y los Prefabricados

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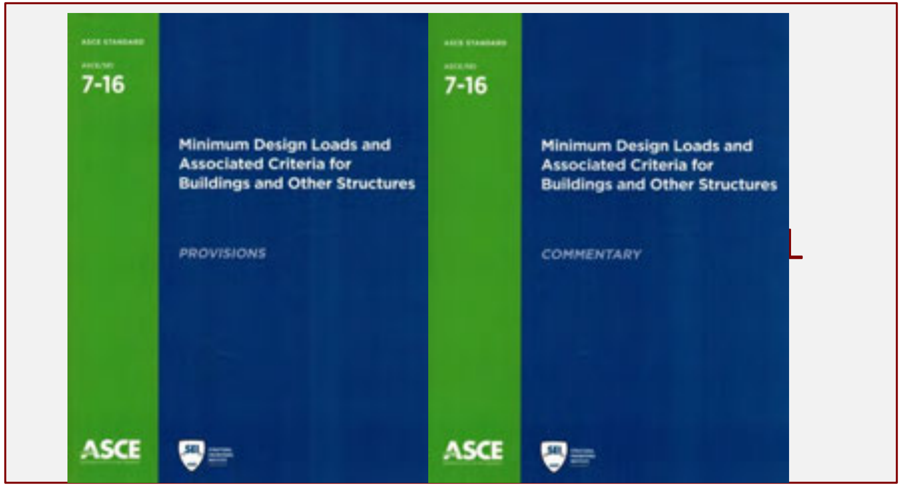


El ASCE 7-16 y la actualización de la NSR

S. K. Ghosh
S. K. Ghosh Associates LLC
U.S.A.

U. S. Codes and Standards

Legal Codes

California Building Code

Model Codes

IBC

Standards

ASCE 7

ACI 318

Resource Documents

NEHRP Provisions

ATC Reports

Ministerio de Vivienda, Ciudad y Territorio
Viceministerio de Vivienda
Dirección del Sistema Habitacional
República de Colombia

COMISIÓN ASESORA PERMANENTE PARA EL RÉGIMEN DE CONSTRUCCIONES SISMO RESISTENTES
(Creada por la Ley 400 de 1997)

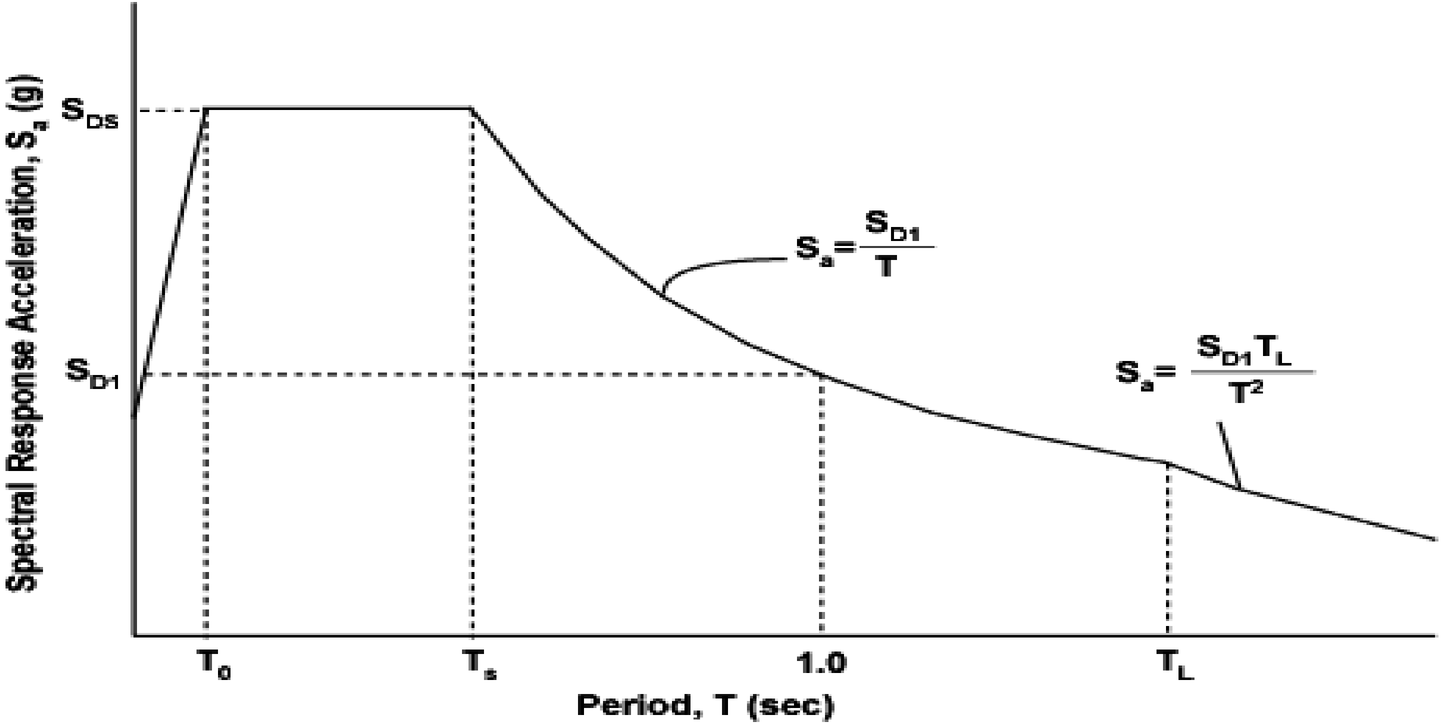
REGLAMENTO COLOMBIANO DE CONSTRUCCIÓN SISMO RESISTENTE

NSR-10

Bogotá D.C., Colombia
Octubre de 2017

Secretaría de la Comisión:
AIS Asociación Colombiana de Ingeniería Sísmica
Carrera 19A N° 84-14, Oficina 502 • Bogotá, D. C., COLOMBIA • Teléfono: +57-1-530-0826 • Fax:+57-1- 530-0827• ascsismica@gmail.com

ASCE 7-16 Figure 11.4-1: Design Response Spectrum



Design Ground Motion Parameters

- S_{DS} = ordinate to the design spectrum at a period of 0.2 sec = (2/3) $F_a S_S$
- S_{D1} = ordinate to the design spectrum at a period of 1.0 sec = (2/3) $F_v S_1$ *Up through ASCE 7-05:*
- S_S = mapped (MCE) spectral response acceleration at short periods for Site Class B
- S_1 = mapped (MCE) spectral response acceleration at 1.0-second period for Site Class B

ASCE 7/ IBC Ground Motion

Maximum Considered Earthquake (MCE)

- 2% probability of exceedance in 50 years (approximately 2,500-year return period) where deterministic approach is not used
- Subject to deterministic cap in coastal California and New Madrid area of the Midwest.

NSR-10 Design Response Spectrum

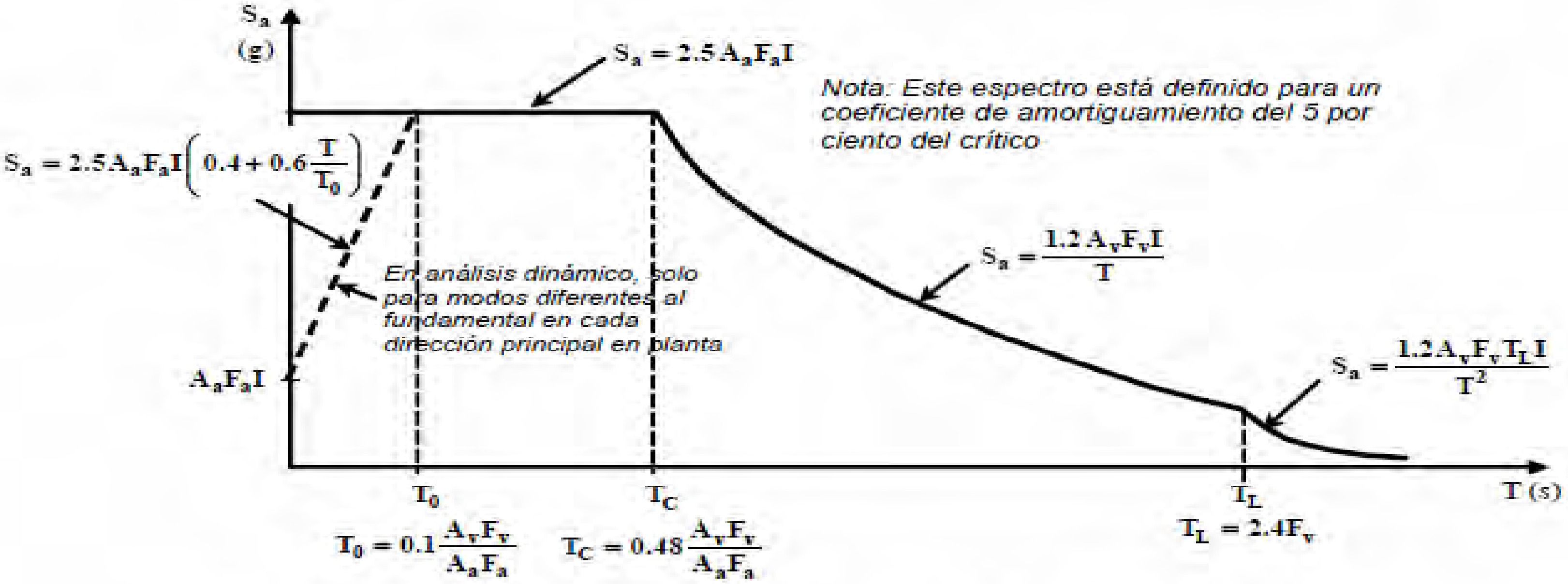


Figura A.2.6-1 — Espectro Elástico de Aceleraciones de Diseño como fracción de g

NSR-10 Design Earthquake Ground Motion

- Approximately 90% probability of non-exceedance in 50 years (approx. 475 yr. return period)

ASCE 7/ NSR-10 Correspondence

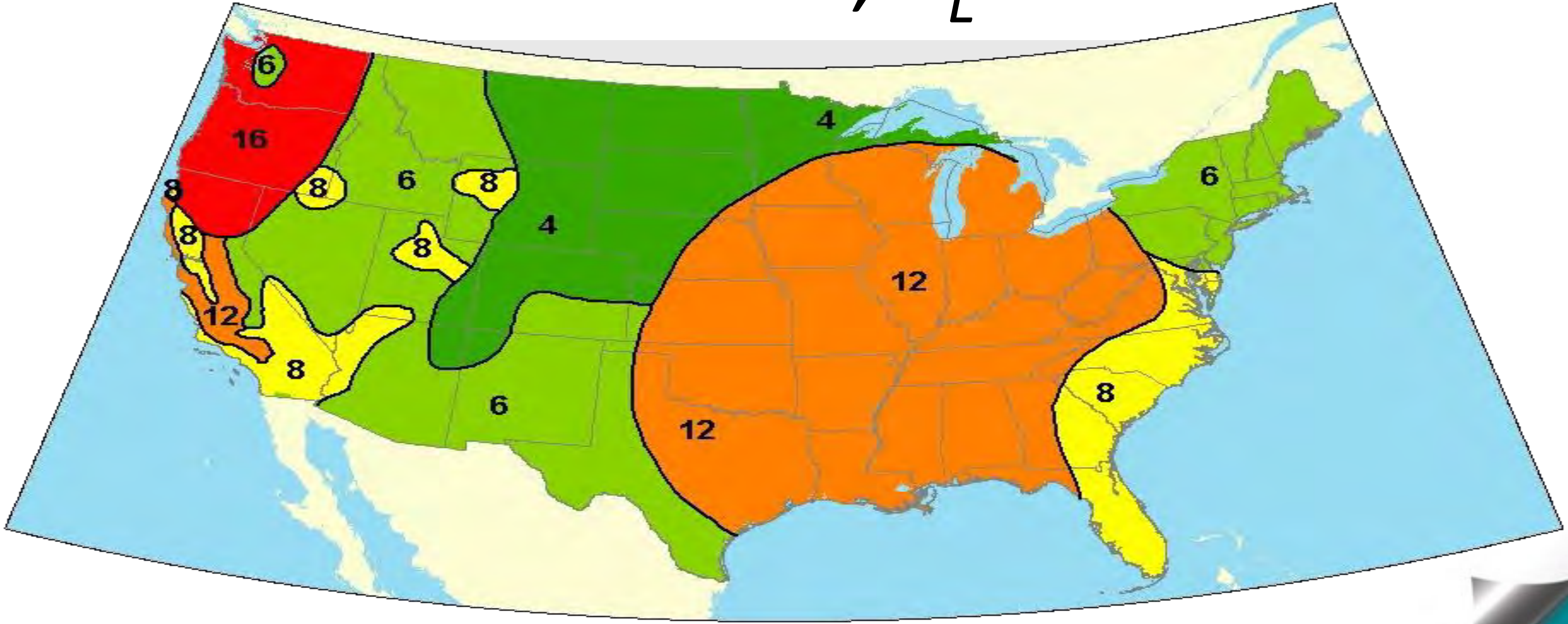
$S_{DS} \leftrightarrow \quad 2.5\, F_a A_a$

$S_{D1} \leftrightarrow \quad F_v A_v$

Also, U.S. – T_L Mapped

Colombia – $T_L = 2.4F_v$

Long-Period Transition Period, T_L



Seismic Ground Motion Updates

ASCE 7-05 to ASCE 7-10

- Risk-Targeted MCE_R maps replaced old MCE maps
- Four changes took place to create these new maps…

Seismic Ground Motion Updates

ASCE 7-05 to ASCE 7-10

CHANGE 1	Updated source zone models and attenuation relationships
CHANGE 2	Switch to risk-targeted ground motion
CHANGE 3	Switch to maximum-direction ground motion
CHANGE 4	Change in deterministic ground motion

Seismic Design Map Updates

CHANGE 2:

Uniform-hazard ground motion was replaced by risk-targeted ground motion.

A switch was made from a 2% in 50-year hazard level to a 1% in 50-year collapse risk target.

Seismic Design Map Updates

CHANGE 3:

A switch was made from “geo-mean” ground motions (square root of the product of ground motions in any two orthogonal directions) to maximum direction ground motions. Short-period ground motion was amplified by a factor of 1.1 and long-period ground motion by a factor of 1.3 (these are scalar multipliers, based on work by Andrew Whittaker).

ASCE 7 Site Classification

Site Class Definitions (ASCE 7-10 Table 20.3-1)

- Class A: Hard rock
- Class B: Rock
- Class C: Very dense soil and soft rock
- Class D: Stiff soil
- Class E: Soft soil
- Class F: Soils requiring site-specific evaluations

Short-Period Site Coefficients of NSR-10

Tabla A.2.4-3

Valores del coeficiente F_a, para la zona de periodos cortos del espectro

Tipo de Perfil	Intensidad de los movimientos sísmicos				
	$A_a \leq 0.1$	$A_a = 0.2$	$A_a = 0.3$	$A_a = 0.4$	$A_a \geq 0.5$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	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	véase nota	véase nota	véase nota	Véase nota	véase nota

Nota: Para el perfil tipo F debe realizarse una investigación geotécnica particular para el lugar específico y debe llevarse a cabo un análisis de amplificación de onda de acuerdo con A.2.10.

Long-Period Site Coefficients of NSR-10

Tabla A.2.4-4
Valores del coeficiente F_V, para la zona de períodos intermedios del espectro

Tipo de Perfil	Intensidad de los movimientos sísmicos				
	$A_V \le 0.1$	$A_V = 0.2$	$A_V = 0.3$	$A_V = 0.4$	$A_V \ge 0.5$
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	véase nota	véase nota	véase nota	Véase nota	véase nota

Nota: Para el perfil tipo **F** debe realizarse una investigación geotécnica particular para el lugar específico y debe llevarse a cabo un análisis de amplificación de onda de acuerdo con A.2.10.

Sec. 11.4.4 - Site Coefficients

New Site Amplification Factors

- First update since 1994 UBC
  - Much more data!
- F_a and F_v range between 80%-120% of previous values
- Site Class D is no longer default for F_a
  - $F_a \geq 1.2$ (strong shaking: Site Class C "controls")

Sec. 11.4.4 - Site Coefficients

Table 11.4-1 Short-Period Site Coefficient, F_a
Mapped Risk-Targeted Maximum Considered Earthquake (MCE_R) Spectral Response Acceleration Parameter at Short Period

Site Class	$S_S \le 0.25$	$S_S = 0.50$	$S_S = 0.75$	$S_S = 1.00$	$S_S = 1.25$	$S_S \ge 1.50$
A	0.8	0.8	0.8	0.8	0.8	0.8
B	~~1.0~~ 0.9	~~1.0~~ 0.9	~~1.0~~ 0.9	~~1.0~~ 0.9	~~1.0~~ 0.9	~~1.0~~ 0.9
C	~~1.2~~ 1.3	~~1.2~~ 1.3	~~1.1~~ 1.2	~~1.0~~ 1.2	~~1.0~~ 1.2	~~1.0~~ 1.2
D	1.6	1.4	1.2	1.1	1.0	1.0
E	~~2.5~~ 2.4	1.7	~~1.2~~ 1.3	~~0.9~~ *See Section 11.4.8*		
F	*See Section 11.4.8*					

Note: Use straight-line interpolation for intermediate values of S_S.

Sec. 11.4.4 - Site Coefficients

11.4.4 Site Coefficients and Risk-Targeted Maximum Considered Earthquake (MCE_R) Spectral Response Acceleration Parameters

… Where Site Class D is selected as the default site class per Section 11.4.3, the value of F_a shall not be less than 1.2.

Sec. 11.4.4 - Site Coefficients

Table 11.4-2 Long-Period Site Coefficient, F_v
Mapped Risk-Targeted Maximum Considered Earthquake (MCE_R) Spectral Response Acceleration Parameter at 1-sec Period

Site Class	$S_1 \le 0.1$	$S_1 = 0.2$	$S_1 = 0.3$	$S_1 = 0.4$	$S_1 = 0.5$	$S_1 \ge 0.6$
A	0.8	0.8	0.8	0.8	0.8	0.8
B	~~1.0~~ 0.8	~~1.0~~ 0.8	~~1.0~~ 0.8	~~1.0~~ 0.8	~~1.0~~ 0.8	~~1.0~~ 0.8
C	~~1.7~~ 1.5	~~1.6~~ 1.5	1.5	~~1.4~~ 1.5	~~1.3~~ 1.5	~~1.3~~ 1.4
D	2.4	~~2.0~~ 2.2[a]	~~1.8~~ 2.0[a]	~~1.6~~ 1.9[a]	~~1.5~~ 1.8[a]	~~1.5~~ 1.7[a]
~~E~~	~~3.5~~	~~3.2~~	~~2.8~~	~~2.4~~	~~2.4~~	~~2.4~~
E	4.2	*See Section 11.4.8*				
F	*See Section 11.4.8*					

Note: [a]Also, see requirements for site-specific ground motions in *Section 11.4.8*.

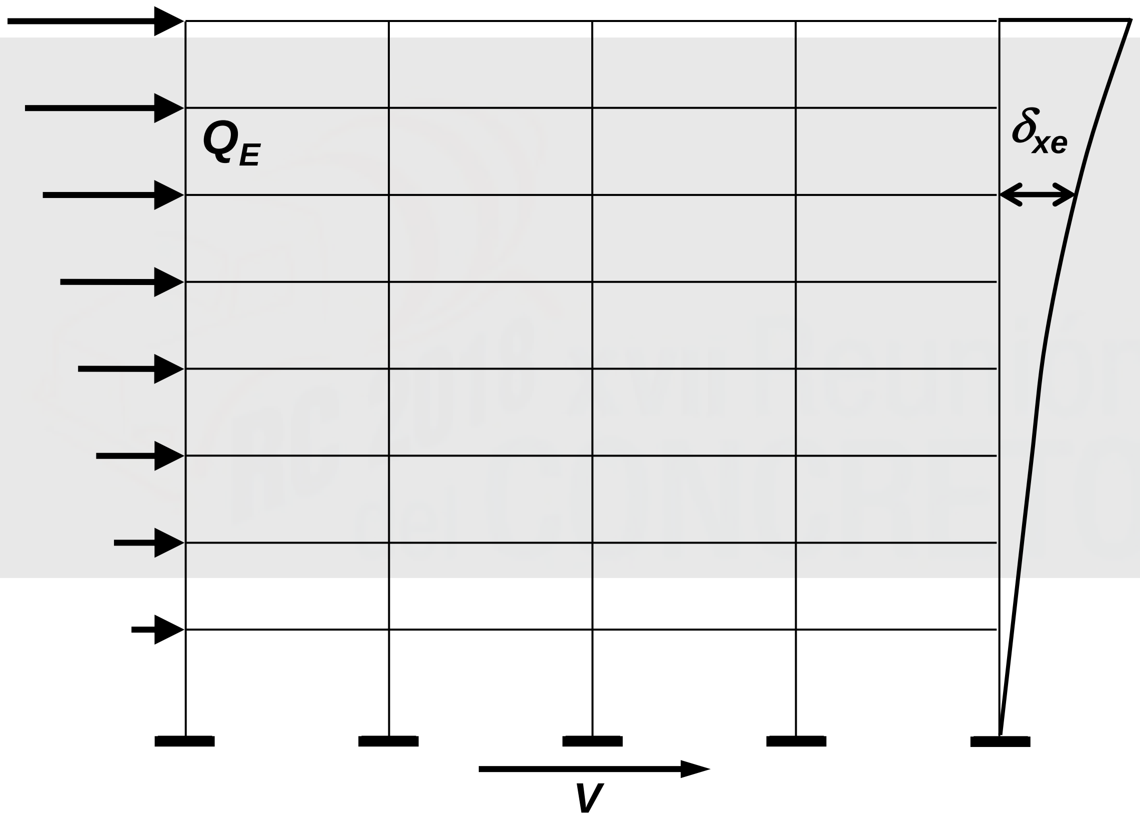
Note: Use straight-line interpolation for intermediate values of S_1.

IBC/ASCE 7 Seismic Strength Design

Load Combinations

- $1.2D + 1.0E + f_1L + f_2S$ Equation (16-5)
- $0.9D + 1.0E$ Equation (16-7)
- $E = \rho Q_E + 0.2S_{DS}D$ in Equation (16-5)
- $E = \rho Q_E - 0.2S_{DS}D$ in Equation (16-7)
- $\rho = 1$ in Seismic Design Category (SDC) A, B and C

Analysis of Structures under Code-Prescribed Seismic Forces



Effect of Vertical Earthquake Ground Motion

- Gravity and Earthquake Effects Additive

$$U = 1.2D + 1.0E + f_1L + f_2S$$

$$= 1.2D + (\rho Q_E + 0.2S_{DS}D) + f_1L + f_2S$$

$$= (1.2 + 0.2S_{DS})D + \rho Q_E + f_1L + f_2S$$

Effect of Vertical Earthquake Ground Motion

- Gravity and Earthquake Effects Counteractive

$$U = 0.9D + 1.0E$$

$$= 0.9D + (\rho Q_E - 0.2S_{DS}D)$$

$$= (0.9 - 0.2S_{DS})D + \rho Q_E$$

Horizontal Cantilevers

12.4.4 Minimum Upward Force for Horizontal Cantilevers for Seismic Design Categories D trough F. In structures assigned to Seismic Design Category D, E, or F, horizontal cantilever structural components shall be designed for a minimum net upward force of 0.2 times the dead load in addition to the applicable load combinations in Section 12.4.

Horizontal Cantilever

Basic Combinations for Strength Design:

a. $(1.2 + 0.2S_{DS})D + \rho Q_E + L + 0.2S$

b. $(0.9 - 0.2S_{DS})D + \rho Q_E + 1.6H$

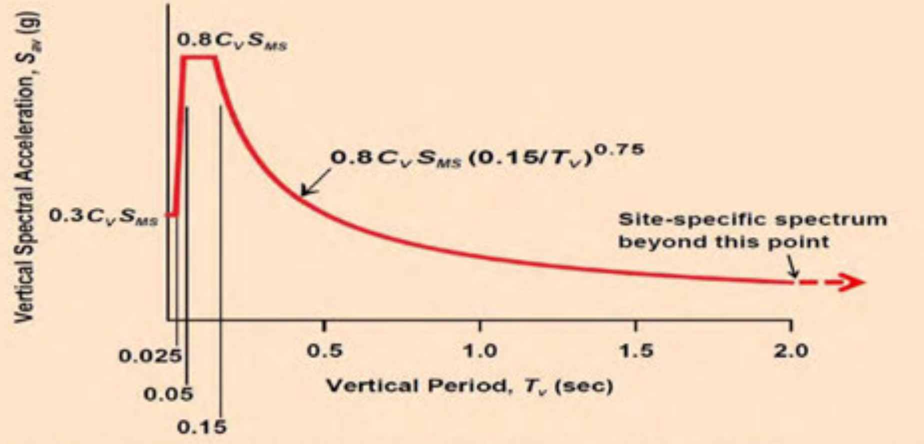
c. $-0.2D$

Sec. 11.9 - Vertical Ground Motions

- Section 11.9 provides ***OPTIONAL*** vertical ground motions in lieu of Section 12.4.2.2 (E_v) for SDC C through F
- Keyed to S_{MS} (MCE$_R$-level ground motions)
- Design spectrum taken as 2/3 MCE$_R$ spectrum

Sec. 11.9 - Vertical Ground Motions

MCE_R Response Spectrum



S_{av} shall be less than one-half (1/2) of the corresponding S_a for horizontal components determined in accordance with the site-specific procedure of ASCE 7-05 Chapter 21

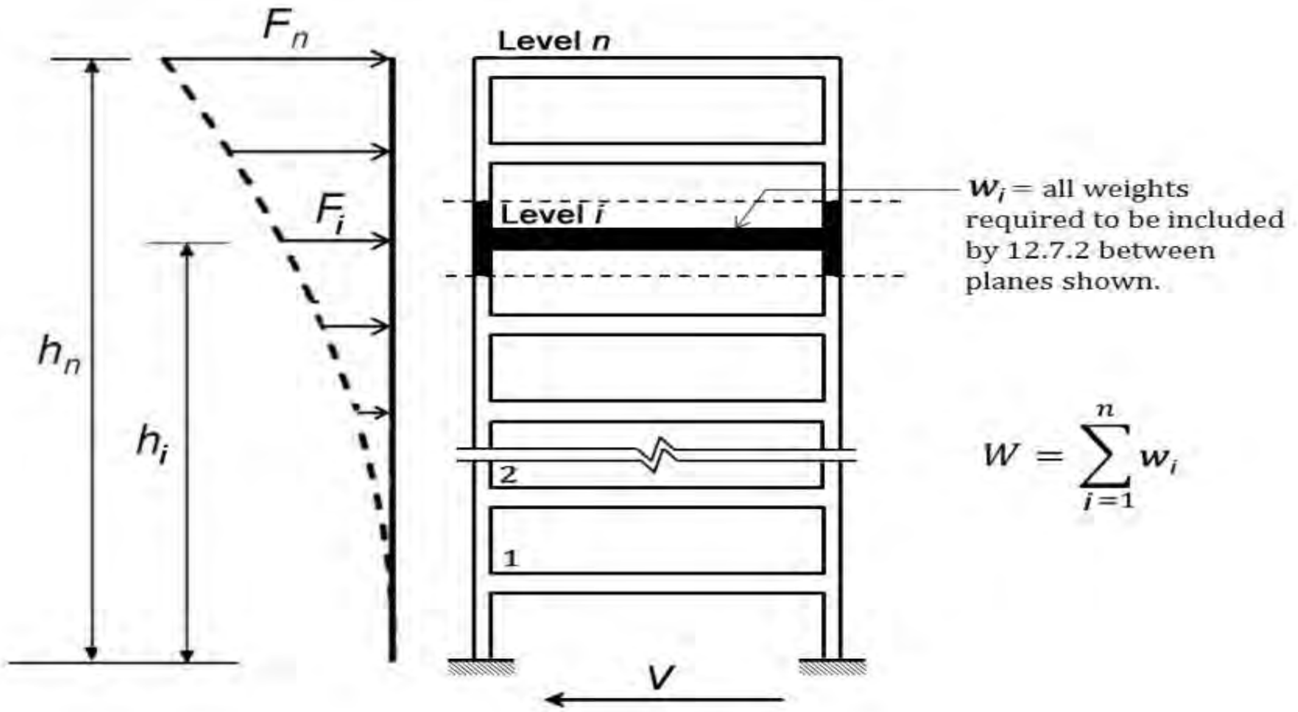
MCE Spectral Response Parameter at Short Periods[a]	Site Class A, B	Site Class C	Site Class D, E, F
$S_s \geq 2.0$	0.9	1.3	1.5
$S_s = 1.0$	0.9	1.1	1.3
$S_s = 0.6$	0.9	1.0	1.1
$S_s = 0.3$	0.8	0.8	0.9
$S_s \leq 0.2$	0.7	0.7	0.7

[a] Use straight-line interpolation for intermediate values of S_S.

Sec. 12.9.1.4.1 – Scaling of Forces

- The base shear (*V*) shall be calculated in each of the two orthogonal directions using fundamental period *T* and Sec. 12.8.
- Where calculated fundamental period exceeds $C_u T_a$ in a given direction, $C_u T_a$ shall be used in lieu of *T* in that direction.
- Where the combined response for the modal base shear (V_t) is less than 100 percent of the calculated base shear (*V*) using the equivalent lateral force procedure, the forces shall be multiplied by V/V_t. (Used to permit 85 percent)

Diaphragms, Chords, and Collectors



Diaphragms, Chords, and Collectors

12.10.1.1 Diaphragm Design Forces. Floor and roof diaphragms shall be designed to resist design seismic forces from the structural analysis, but not less than t

$$0.2S_{DS}Iw_{px} \le F_{px} = \frac{\sum_{i=x}^{n} F_i}{\sum_{i=x}^{n} w_i} w_{px} \le 0.4S_{DS}Iw_{px}$$

Where

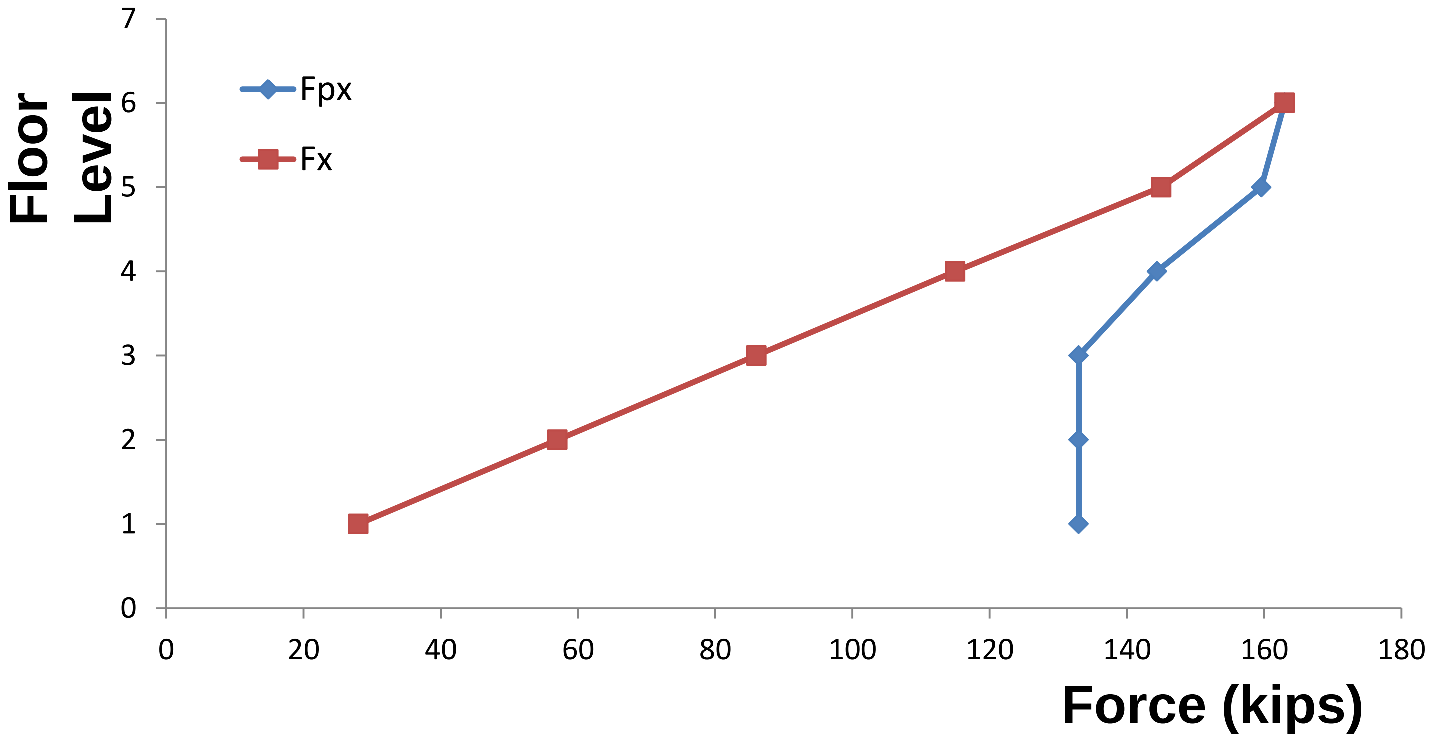
F_{px} = the diaphragm design force

F_i = the design force applied to Level *i*

w_i = the weight tributary to Level *i*

w_{px} = the weight tributary to the diaphragm at Level *x*

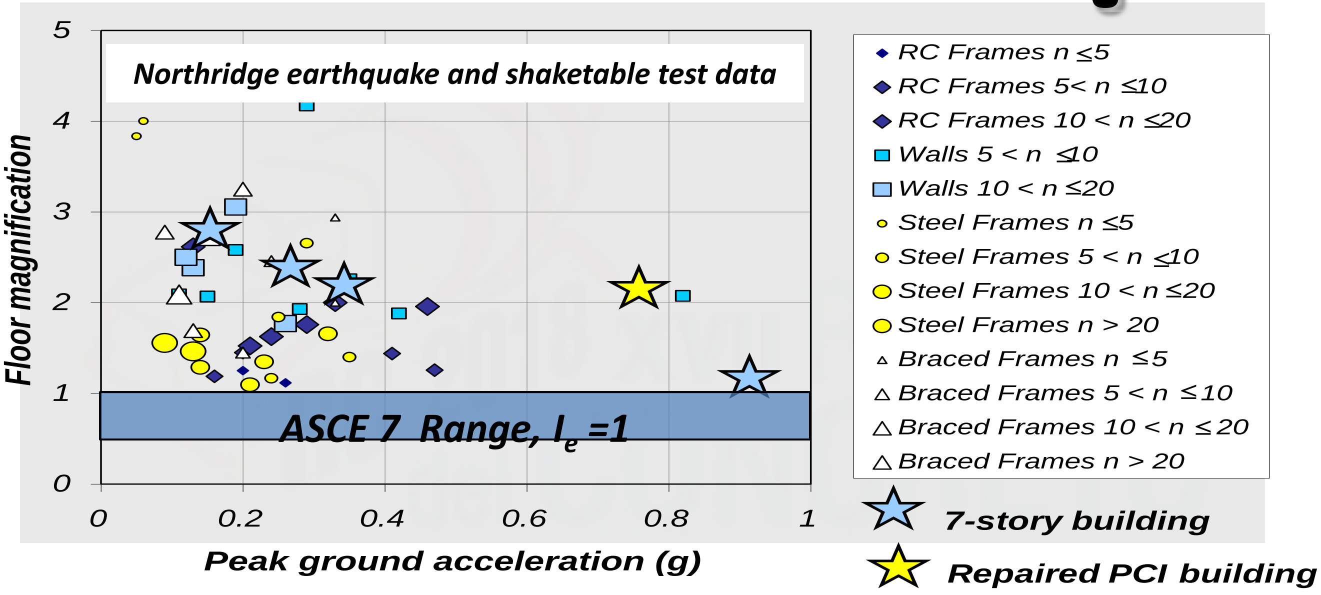
Diaphragm Design Forces



Floor Accelerations for Diaphragm Design

ASCE 7 Method

$0.5\, I_e \leq \text{Acceleration "Magnification"} \leq 1.0\, I_e$?



- The upper and lower limits in ASCE7 do not seem to be rational
- The computation of floor acclerations based on the assumption that all modes are equally reduced by plasticity does not seem rational either

Diaphragm Design

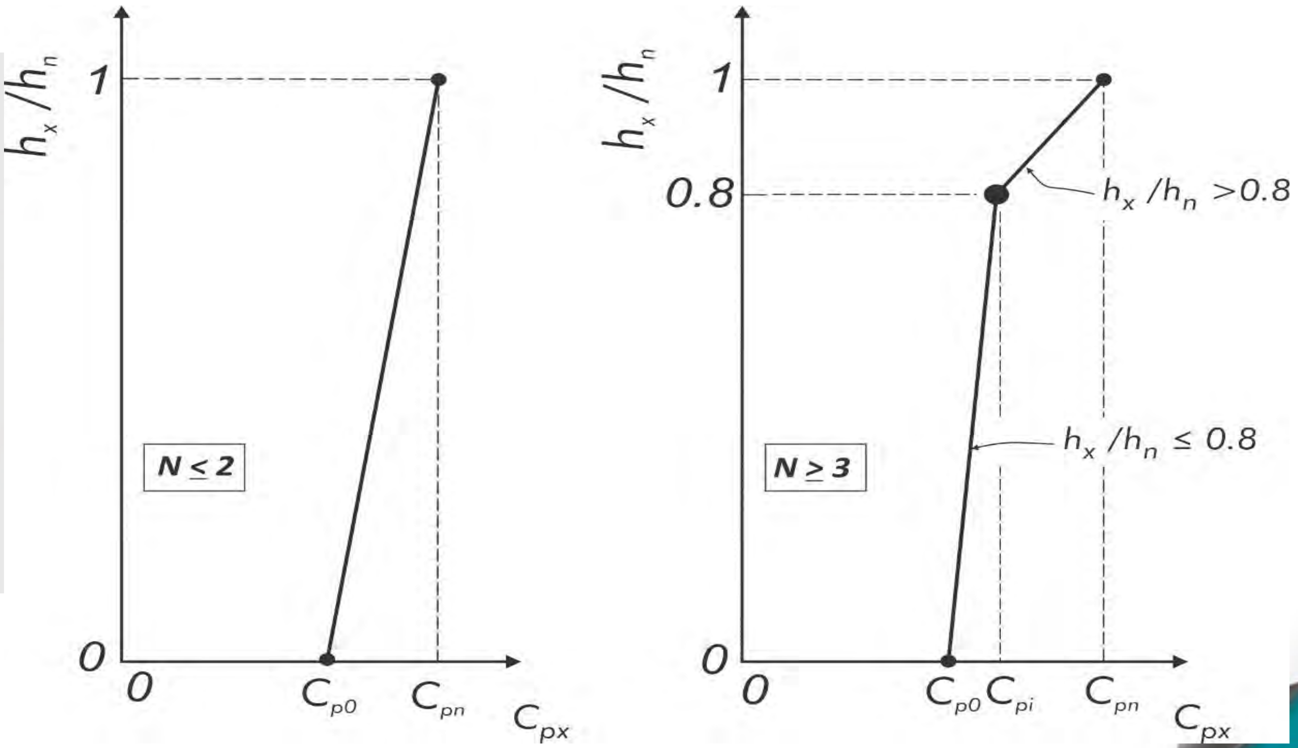
$$F_{px} = C_{px} w_{px} / R_s$$

$$\geq 0.2 S_{DS}\, I_e\, w_{px}$$

C_{px} comes from C_{p0}, C_{pi}, and C_{pn}

Diaphragm Design

ASCE 7-16



Diaphragm Design

Flexure-controlled diaphragm: Diaphragm with a well-defined flexural yielding mechanism, which limits the force that develops in the diaphragm.

The factored shear resistance shall be greater than the shear corresponding to flexural yielding.

Diaphragm Design

Shear-controlled diaphragm: Diaphragm that does not meet the requirements of a flexure-controlled diaphragm.

Diaphragm Design Force Reduction Factor, R_s

Diaphragm System		Shear-Controlled	Flexure-Controlled
Cast-in-place concrete designed in accordance with Section 14.2 and ACI 318	-	1.5	2
Precast concrete designed in accordance with Section 14.2.4 and ACI 318	EDO [1]	0.7	0.7
	BDO [2]	1.0	1.0
	RDO [3]	1.4	1.4
Wood sheathed designed in accordance with Section 14.5 and AF&PA (now AWC) *Special Design Provisions for Wind and Seismic*	-	3.0	NA

1. EDO is precast concrete diaphragm Elastic Design Option.
2. BDO is precast concrete diaphragm Basic Design Option.
3. RDO is precast concrete diaphragm Reduced Design Option.

Acknowledgment

Visit made possible by

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of the American Society of Civil Engineers (ASCE)

SEI Overview

The Structural Engineering Institute of ASCE was founded in 1996

- More than 34,000 members in more than 100 countries
- The mission of SEI is to advance and serve structural engineering

SEI Overview

One of 9 specialty Institutes of ASCE:

- AEI — ARCHITECTURAL ENGINEERING INSTITUTE
- CI — CONSTRUCTION INSTITUTE
- COPRI — COASTS, OCEANS, PORTS & RIVERS INSTITUTE
- EMI — ENGINEERING MECHANICS INSTITUTE
- EWRI — ENVIRONMENTAL & WATER RESOURCES INSTITUTE
- G-I — GEO-INSTITUTE
- SEI — STRUCTURAL ENGINEERING INSTITUTE
- T&DI — TRANSPORTATION & DEVELOPMENT INSTITUTE
- UESI — UTILITY ENGINEERING & SURVEYING INSTITUTE

Thank You!!

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