VOLUME 2

2009 IBC®

SEAOC STRUCTURAL/SEISMIC DESIGN MANUAL

BUILDING DESIGN EXAMPLES FOR
LIGHT-FRAME, TILT-UP AND MASONRY

STRUCTURAL ENGINEERS ASSOCIATION CALIFORNIA

STRUCTURAL ENGINEERS ASSOCIATIONS NATIONAL COUNCIL

ICC INTERNATIONAL CODE COUNCIL®

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Publisher

Structural Engineers Association of California (SEAOC)
1400 K Street, Ste. 212
Sacramento, California 95814
Telephone: (916) 447-1198; Fax: (916) 444-1501
E-mail: dschinske@seaoc.org; Web address: www.seaoc.org

The Structural Engineers Association of California (SEAOC) is a professional association of four regional member organizations (Southern California, Northern California, San Diego, and Central California). SEAOC represents the structural engineering community in California. This document is published in keeping with SEAOC's stated mission: "to advance the structural engineering profession; to provide the public with structures of dependable performance through the application of state-of-the-art structural engineering principles; to assist the public in obtaining professional structural engineering services; to promote natural hazard mitigation; to provide continuing education and encourage research; to provide structural engineers with the most current information and tools to improve their practice; and to maintain the honor and dignity of the profession."

Editor

International Code Council

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Preface

This is the second volume in the three-volume 2009 *IBC SEAOC Structural/Seismic Design Manual.* It has been developed and funded by the Structural Engineers Association of California (SEAOC). Its purpose is to provide guidance on the interpretation and use of the seismic requirements in the 2009 *International Building Code* (IBC), published by the International Code Council, Inc., and SEAOC's 2005 *Recommended Lateral Force Requirements and Commentary* (also called the Blue Book).

The 2009 *IBC SEAOC Structural/Seismic Design Manual* was developed to fill a void that exists between the commentary of SEAOC's Blue Book, which explained the basis for the code provisions, and everyday structural engineering design practice. The 2009 *IBC SEAOC Structural/Seismic Design Manual* illustrates how the provisions of the code are used. *Volume 1: Code Application Examples,* provides step-by-step examples for using individual code provisions, such as computing base shear or building period. *Volumes 2 and 3: Building Design Examples,* furnish examples of seismic design of common types of buildings. In Volumes 2 and 3, important aspects of whole buildings are designed to show, calculation-by-calculation, how the various seismic requirements of the code are implemented in a realistic design.

The examples in the 2009 *IBC SEAOC Structural/Seismic Design Manual* do not necessarily illustrate the only appropriate methods of design and analysis. Proper engineering judgment should always be exercised when applying these examples to real projects. The 2009 *IBC Structural/Seismic Design Manual* is not meant to establish a minimum standard of care but, instead, presents reasonable approaches to solving problems typically encountered in structural/seismic design.

The example numbers used in the prior manual—2006 *IBC Structural/Seismic Design Manual: Volume 2: Building Design Examples*—have been retained herein to provide easy comparison to revised code requirements.

SEAOC and ICC intend to update the *IBC SEAOC Structural/Seismic Design Manual* with each new edition of the building code.

Acknowledgments

Authors

The 2009 *IBC SEAOC Structural/Seismic Design Manual—Volume 2* was written by a group of highly qualified structural engineers. They were selected by a steering committee set up by the SEAOC Board of Directors and were chosen for their knowledge and experience with structural engineering practice and seismic design. The consultants for Volumes 1, 2, and 3 are:

Jon P. Kiland, *Co-Project Manager*
Rafael Sabelli, *Co-Project Manager*
Douglas S. Thompson
Dan Werdowatz
John W. Lawson
Joe Maffei
Kevin Moore
Stephen Kerr
Karl Teleen

Reviewers

A number of SEAOC members and other structural engineers helped check the examples in this volume. During its development, drafts of the examples were sent to these individuals. Their help was sought in review of code interpretations as well as detailed checking of the numerical computations.

Seismology Committee

Close collaboration with the SEAOC Seismology Committee was maintained during the development of the document. The Seismology Committee has reviewed the document and provided many helpful comments and suggestions. Their assistance is gratefully acknowledged.

Production and Art

ICC

Suggestions for Improvement

In keeping with SEAOC's Mission Statement: "to advance the structural engineering profession" and "to provide structural engineers with the most current information and tools to improve their practice," SEAOC plans to update this document as structural/seismic requirements change and new research and better understanding of building performance in earthquakes becomes available.

Comments and suggestions for improvements are welcome and should be sent to the following:

Structural Engineers Association of California (SEAOC)
Attention: Executive Director
1020 12th Street, Suite 303
Sacramento, California 95814
Telephone: (916) 447-1198; Fax: (916) 444-1501
E-mail: lee@seaoc.org; Web address: www.seaoc.org

Errata Notification

SEAOC has made a substantial effort to ensure that the information in this document is accurate. In the event that corrections or clarifications are needed, these will be posted on the SEAOC web site at *http://www.seaoc.org* or on the ICC web site at *http://www.iccsafe.org*. SEAOC, at its sole discretion, may or may not issue written errata.

Introduction

The 2009 *IBC SEAOC Structural/Seismic Design Manual* is intended to help the reader understand and correctly use the IBC structural/seismic provisions and to provide clear, concise, and graphic guidance on the application of specific provisions of the code. It primarily addresses the major structural/seismic provisions of the IBC, with interpretation of specific provisions and examples highlighting their proper application.

The 2009 IBC has had structural provisions removed from its text and has referenced several national standards documents for structural design provisions. The primary referenced document is ASCE/SEI 7-05, which contains the "Minimum Design Loads for Buildings and Other Structures." ASCE/SEI 7-05 is referenced for load and deformation design demands on structural elements, national material design standards (such as ACI, AISC, MSJC and NDS) are then referenced to take the structural load demands from ASCE/SEI 7-05 and perform specific material designs.

The complete 2009 *IBC SEAOC Structural/Seismic Design Manual* will have three volumes. Volume 1 illustrates the application of specific provisions of ASCE 7 and the IBC. Volumes 2 and 3 will provide a series of structural/seismic design examples for buildings illustrating the seismic design of key parts of common building types such as a large three-story wood frame building, a tilt-up warehouse, a braced steel frame building, and a concrete shear wall building.

While the 2009 *IBC SEAOC Structural/Seismic Design Manual* is based on the 2009 IBC, there are some provisions of SEAOC's *Recommended Lateral Force Provisions and Commentary* (Blue Book) that are applicable. When differences between the IBC and Blue Book are significant, they are brought to the attention of the reader.

The 2009 *IBC SEAOC Structural/Seismic Design Manual* is intended for use by practicing structural engineers and structural designers, building departments, other plan review agencies, and structural engineering students.

How to Use This Document

ASCE/SEI 7-05 notation is generally used throughout. Some other notation is also defined in the following pages, or in the examples.

Throughout the document, reference to specific code provisions and equations is given in the right-hand margin under the category Code Reference. For example, "ASCE/SEI 7-05 Section 12.3" is given as §12.3 with ASCE/SEI 7-05 being understood. "Equation (12-4-1)" is designated Eq 12.4-1. The phrase "T 15.2.1" is understood to be Table 15.2.1 and Figure 22-1 is designated F 22-1.

The 2009 *IBC SEAOC Structural/Seismic Design Manual—Volume 2* primarily references the ASCE/SEI 7-05, unless otherwise indicated. References to IBC sections, tables, and equations are enclosed in parentheses. Occasionally, reference is made to other codes and standards (e.g., ACI 318-08 or 2005 NDS). When this is so, these documents are clearly identified.

Generally, each design example is presented in the following format. First, there is an "Overview" of the example. This is a description of the building to be designed. This is followed by an "Outline" indicating the tasks or steps to be illustrated in each example. Next, "Given Information" provides the basic design information, including plans and sketches given as the starting point for the design. This is followed by "Calculations and Discussion," which provides the solution to the example. Some examples have a subsequent section designated "Commentary" that is intended to provide a better understanding of aspects of the example and/or to offer guidance to the reader on use of the information generated in the example. Finally, references and suggested reading are given under "References." Some examples also have a "Foreword" and/or "Factors Influencing Design" section that contains remarks on salient points about the design.

Notation

The following notations are used in this document. These are generally consistent with those used in the ASCE/SEI 7-05 and other codes such as ACI and AISC. The reader is cautioned that the same notation may be used more than once and may carry entirely different meanings in different situations. For example, E can mean the tabulated elastic modulus under the AISC definition (steel) or it can mean the earthquake load under §12.4.2 of the ASCE/SEI 7-05. When the same notation is used in two or more definitions, each definition is prefaced with a brief description in parentheses (e.g., steel or loads) before the definition is given.

A	=	area of floor or roof supported by a member
A	=	area of element or member
A_b	=	(steel) area of anchor, in square inches
A_g	=	gross area of section
A_g	=	the gross area of that wall in which A_o is identified
A_i	=	the floor area in square feet of the diaphragm level immediately above the story under consideration
A_o	=	total area of opening in a wall that receives positive external wind pressure
A_s	=	area of tension reinforcement
A_x	=	the torsional amplification factor at Level x – §12.8.4.3
a	=	(concrete, masonry) depth of equivalent rectangular stress block
a	=	(wind) edge strip width, ASCE 7 Figures 6-2, 6-3
B_n	=	(masonry)
b	=	(concrete) width of compression face of member
b	=	(wood) length(width) of wall
C_d	=	deflection amplification factor in Tables 12.2-1 or 15.4-1 or 15.4-2
C_D	=	(wood) duration of load factor
C_e	=	snow exposure factor
C_O	=	(wood) shear capacity adjustment factor, SDPWS 4.3.3.5

C_s = the seismic response coefficient determined in §12.8.1.1

C_t = building period coefficient – §12.8.2.1

C_t = snow thermal factor

C_V = (wood) glulam volume factor

C_{vx} = vertical distribution factor – §12.8.3

c = distance from extreme compression fiber to neutral axis of a flexural member

D = dead load, the effect of dead load

d = effective depth of section (distance from extreme compression fiber to centroid of tension reinforcement)

d_b = (concrete) bar diameter

E = (steel) modulus of elasticity

E = combined effect of horizontal and vertical earthquake induced forces (§12.4)

E_c = modules of elasticity of concrete, in psi

E_h = horizontal seismic load effect

EI = flexural stiffness of compression member

E_m = seismic load effect including overstrength factors (§§12.4.3 and 12.14.3.2)

E_m = (masonry) modulus of elasticity

E_n = (wood) fastener slip/nail deformation

E_s = (concrete) modulus of elasticity of reinforcement

F = load due to fluids

F_a = site coefficient defined in §11.4.3

F_a = axial compressive stress that would be permitted if axial force alone existed

F_b = bending stress that would be permitted if bending moment alone existed

F_b = (wood) reference bending design value

F_b' = (wood) adjusted bending design value

F_i, F_n, F_x	=	portion of the seismic base shear, V, induced at Level i, n, or x (§12.8.3)
F_i	=	the design force applied to Level i
F_p	=	seismic design force, induced by the parts being connected, centered at the component's center of gravity, and distributed relative to the component's mass distribution as in §§12.8.3 and 12.11.1
F_{px}	=	diaphragm design force, §12.10.1.1
F_u	=	specified minimum tensile strength, ksi
F_v	=	long period site coefficient (at 1.0 second period) §11.4.3
F_v	=	(wood) reference shear design value
F_v'	=	(wood) adjusted shear design value
F_x	=	the design lateral force applied at Level x
F_x	=	the lateral force induced at any Level i – §12.8.3
F_y	=	specified yield strength of structural steel
f_1	=	live load reduction factor – IBC §1605
f_a	=	axial stress in frame member
f_b	=	bending stress in frame member
f_c'	=	specified compressive strength of concrete
f_m'	=	specified compressive strength of masonry
f_r	=	(concrete, masonry) modulus of rupture
f_y	=	specified yield strength of steel
G	=	(masonry) modulus of rigidity
G_a	=	(wood) apparent shear wall stiffness
g	=	acceleration due to gravity (gravitational acceleration constant 32.2 ft/sec^2 or 386.4 in/sec^2)
H	=	load due to lateral pressure of soil and water in soil
h	=	average roof height of structure relative to the base elevation
h	=	wall height (ft)
h_n	=	height above base to highest level of structure §12.8.2.1

h_i, h_n, h_x	=	height in feet above the base to Level i, n or x, respectively
h_{sx}	=	the story height below Level x
h_w	=	height of entire wall or of the segment of wall considered
I	=	seismic occupancy importance factor determined in §11.5.1
I	=	moment of inertia of section resisting externally applied factored loads (in^4)
I	=	wind importance factor determined in Table 6-1
I_{cr}	=	(concrete) moment of inertia of cracked section
I_g	=	(concrete, neglecting reinforcement) moment of inertia of gross concrete section about centroidal axis neglecting reinforcement
I_{se}	=	moment of inertia of reinforcement about centroidal axis of member cross section.
K	=	(steel) effective length factor for prismatic member
K_{zt}	=	(wind) topographic factor, §6.5.7
k	=	a distribution exponent – §12.8.3
k	=	(wood) rigidity constant for shear wall or cantilevered column
L	=	live load, except roof live load, including any permitted live load reduction (i.e. reduced design live load).
L_o	=	unreduced design live load
L_r	=	roof live load including any permitted live load reduction
l	=	wall length (ft)
l_u	=	unsupported length of compression member
l_w	=	length of entire wall, or of segment of wall considered, in direction of shear force
Level i	=	level of the structure referred to by the subscript i. "$i = 1$" designates the first level above the base
Level n	=	that level that is uppermost in the main portion of the structure
Level x	=	that level that is under design consideration. "$x = 1$" designates the first level above the base

M	=	(steel) maximum factored moment
M_a	=	(concrete) applied moment = $M_{oop} + M_{ecc}$
M_{cr}	=	moment at which flexural cracking occurs in response to externally applied loads
M_{ecc}	=	(concrete) applied moment due to eccentricity
M_n	=	(steel) nominal moment strength at section
M_{oop}	=	(concrete) applied out-of-plane moment
M_{ot}	=	(wood) overturning moment
M_p	=	(steel) nominal plastic flexural strength
M_R	=	(wood) resistive moment
M_u	=	(concrete, masonry) factored moment at section
M_u	=	(steel) required flexural strength on a member or joint
M_y	=	moment corresponding to onset of yielding at the extreme fiber from an elastic stress distribution
N	=	number of stories
P	=	axial load
P_{as}	=	(steel) allowable shear strength per screw
P_{DL}, P_{LL}, P_{seis}	=	unfactored axial load in frame member
P_n	=	nominal axial load strength at given eccentricity, or nominal axial strength of a column
P_{ns}	=	(steel) nominal shear strength per screw
P_u	=	(concrete) factored axial load, or factored axial load at given eccentricity
P_u	=	(steel) nominal axial strength of a column, or required axial strength of a column or a link
P_y	=	nominal axial yield strength of a member, which is equal to $F_y A_g$
P_x	=	total unfactored vertical design load at and above Level x
p_{net}	=	net design wind pressure

p_{net30}	=	net design wind pressure for Exposure B, at $h = 30$ ft, and for $I = 1.0$, from Fig. 6-3
p_s	=	simplified design wind pressure for MWFRS
p_{s30}	=	simplified design wind pressure for Exposure B, at $h = 30$ ft, and for $I = 1.0$, from Fig. 6-2
Q_E	=	effect of horizontal seismic forces
q	=	(steel) approximate uniform axial load on collector
q_{root}	=	reaction at roof level
R	=	response modification factor from Table 12.2-1 or 15.4-1 or 15.4-2
R_n	=	nominal strength
R_{ot}	=	(wood) overturning reaction
R, R_1 R_2	=	live load reduction in percent – IBC §§1607.9.2 & 1607.11.2
r	=	(steel) radius of gyration of cross section of a compression member
S	=	snow load
S	=	section modulus (in^3)
SDC	=	seismic design category
S_{DS}	=	design, 5% damped, spectral response acceleration parameter at short period (0.2 second) as determined in §11.4.4
S_S, S_s	=	the mapped MCE, 5% damped, spectral response acceleration parameter at short period (0.2 second) as determined in §11.4.1
S_{D1}	=	design, 5% damped, spectral response acceleration parameter at long design (1-second period) as determined in §11.4.4
S_1	=	the mapped MCE, 5% damped, spectral response acceleration parameter at long period (1-second period) as determined in §11.4.1
S_{MS}	=	adjusted MCE, 5% damped, spectral response acceleration parameter at short period (0.2 second), adjusted for site class effects as determined in §11.4.3
S_{M1}	=	adjusted MCE, 5% damped, spectral response acceleration parameter at long period (1-second period), adjusted for site class effects as determined in §11.4.3
T	=	elastic fundamental period of vibration, in seconds, of the structure in the direction under consideration, see §12.8.2

T	=	(masonry) design anchorage tension force
T_a	=	approximate fundamental period as determined in accordance with §12.8.2.1
T_S	=	(S_{D1} / S_{DS})
T_x, T_y	=	(wood) torsional shear
t	=	uniform anchor force, perforated shear wall
U	=	required strength to resist factored loads or related internal moments and forces
V	=	the total design seismic lateral force or shear at the base of the building or structure
V_c	=	(concrete) nominal shear strength provided by concrete
V_m	=	nominal shear strength provided by masonry
V_n	=	(concrete, masonry) nominal shear strength at section
V_n	=	(steel) nominal shear strength of a member
V_{px}	=	the portion of the seismic shear force at the level of the diaphragm, required to be transferred to the components of the vertical seismic-lateral-force-resisting system because of the offsets or changes in stiffness of the components above or below the diaphragm
V_s	=	(concrete, masonry) nominal shear strength provided by reinforcement
V_u	=	(concrete) factored shear force at section
V_u	=	(loads) factored horizontal shear in a story
V_u	=	(steel) required shear strength on a member
V_x	=	the seismic design story shear (force) in story x, (i.e., between Level x and x-1)
v	=	diaphragm shear, §12.10.1
v	=	wall shear at element level
W_{floor}	=	weight of diaphragm and tributary walls above and below
W_{roof}	=	weight of diaphragm and tributary walls
W	=	the total effective seismic dead load (weight) defined in §12.7.2 and §12.14.8.1

W	=	(wind) load due to wind pressure
w_c	=	weight of concrete, in pcf
w_i, w_x	=	that portion of W located at or assigned to Level i or x, respectively §12.8.3, 12.10.1.1
w_p	=	the weight of the smaller portion of the structure
w_p	=	the weight of the diaphragm and other elements of the structure tributary to the diaphragm
w_{px}	=	the weight of the diaphragm and elements tributary thereto at Level x, including applicable portions of other loads defined in §12.10.1.1
w_w	=	weight of the wall tributary to element
X	=	height of upper support attachment at Level x as measured from the base
x	=	building period coefficient from §12.8.2.1
Y	=	height of lower support attachment at Level y as measured from the base
Z	=	(steel) plastic section modulus
ϕ	=	(concrete) capacity-reduction or strength-reduction factor
ϕ_b	=	(steel) resistance factor for flexure
ϕ_c	=	(steel) resistance factor for compression
ϕ_V	=	resistance factor for shear strength
ρ	=	a redundancy factor obtained in accordance with §12.3.4
λ	=	lightweight aggregate concrete factor; 1.0 for normal-weight concrete, 0.75 for “all lightweight” concrete, and 0.85 for “sand-lightweight” concrete
λ	=	(wind) building height and exposure adjustment factor, Figures 6-2 and 6-3
ℓ	=	wall length (ft)
ℓ_n	=	clear span measured face-to-face of supports
ℓ_u	=	unsupported length of compression member

ℓ_w	=	length of entire wall or of segment of wall considered in direction of shear force
Δ	=	design story drift, shall be computed as the differences of the deflections at the center of mass at the top and bottom of the story under consideration. Note: Where ASD is used, Δ shall be computed using earthquake forces without dividing by 1.4, see §12.8.6
Δ	=	(wood) diaphragm deflection
Δ_a	=	allowable story drift, as obtained from Table 12.12-1
Δ_a	=	(wood) total vertical elongation of anchorage system, SDPWS §4.3.2
Δ_c	=	(wood) diaphragm chord splice slip, SDPWS §4.2.2
Δ_{cr}	=	(concrete) out of plane deflection determined using M_{cr}
Δ_n	=	(concrete) out of plane deflection determined using M_n
Δ_S	=	(concrete) out of plane deflection due to maximum moment at mid-height of wall due to service level lateral and eccentric vertical loads including $P\Delta$ effects
Ω_o	=	system overstrength factor as given in Table 12.2-1
δ_x	=	inelastic deflections of Level x – §12.8.6
δ_{ave}	=	the average of the displacements at the extreme points of the structure at Level x
δ_{max}	=	the maximum displacement at Level x
δ_{xe}	=	the deflections determined by an elastic analysis of the seismic-force-resisting system
θ	=	stability coefficient – §12.8.7

Definitions

Active Fault/Active Fault Trace. A fault determined to be active by the authority having jurisdiction from properly substantiated data.

Allowable Stress Design. A method of proportioning structural members, such that elastically computed stresses produced in the members by nominal loads do not exceed specified allowable stresses (also called working stress design).

Attachments, Seismic. Means by which components and their supports are secured or connected to the seismic-force-resisting system of the structure. Such attachments include anchor bolts, welded connections, and mechanical fasteners.

Balcony, Exterior. An exterior floor projecting from and supported by a structure without additional independent supports.

Base. The level at which the horizontal seismic ground motions are considered to be imparted to the structure.

Base Shear. Total design lateral force or shear at the base.

Boundary Elements. Chords and collectors at diaphragm and shear wall edges, interior openings, discontinuities, and re-entrant corners.

Boundary Members. Portions along wall and diaphragm edges strengthened by longitudinal and transverse reinforcement and/or structural steel members.

Brittle. Systems, members, materials, and connections that do not exhibit significant energy dissipation capacity in the inelastic range.

Cantilevered Column System. A structural system relying on column elements that cantilever from a fixed base and have minimal rotational resistance capacity at the top with lateral forces applied essentially at the top and are used for lateral resistance.

Collector. A diaphragm or shear wall element parallel to the applied load that collects and transfers shear forces to the vertical-force-resisting elements or distributes forces within a diaphragm or shear wall.

Collector Elements. Members that serve to transfer forces between floor or horizontal diaphragms and vertical members of the lateral-force-resisting system.

Component. A part or element of an architectural, electrical, mechanical, or structural system.

> **Component, equipment.** A mechanical or electrical component or element that is part of a mechanical and/or electrical system within or without a building system.
>
> **Component, flexible.** Component, including its attachments, having a fundamental period greater than 0.06 second.
>
> **Component, rigid.** Component, including its attachments, having a fundamental period less than or equal to 0.06 second.

Coupling Beam. A beam that is used to connect adjacent concrete wall piers to make them act together as a unit to resist lateral forces.

Dead Loads. The weight of materials of construction incorporated into the building, including but not limited to walls, floors, roofs, ceilings, stairways, built-in partitions, finishes, cladding, and other similarly incorporated architectural and structural items, and fixed service equipment, including the weight of cranes.

Deck. An exterior floor supported on at least two opposing sides by an adjacent structure, and/or posts, piers, or other independent supports.

Deformability. The ratio of the ultimate deformation to the limit deformation.

High deformability element. An element whose deformability is not less than 3.5 when subjected to four fully reversed cycles at the limit deformation.

Limited deformability element. An element that is neither a low deformability nor a high deformability element.

Low deformability element. An element whose deformability is 1.5 or less.

Deformation.

Limit deformation. Two times the initial deformation that occurs at a load equal to 40 percent of the maximum strength.

Ultimate deformation. The deformation at which failure occurs and which shall be deemed to occur if the sustainable load reduces to 80 percent or less of the maximum strength.

Design Earthquake. The earthquake effects that buildings and structures are specifically proportioned to resist.

Design Strength. The product of the nominal strength and a resistance factor (or strength reduction factor).

Diaphragm, Flexible. A diaphragm is flexible for the purpose of distribution of story shear and torsional moment when the lateral deformation of the diaphragm is more than two times the average story drift of the associated story, determined by comparing the computed maximum in-plane deflection of the diaphragm itself under lateral force with the story drift of adjoining vertical lateral-force-resisting elements under equivalent tributary lateral force.

Diaphragm, Rigid. A diaphragm that does not conform to the definition of flexible diaphragm.

Duration of Load. The period of continuous application of a given load, or the aggregate of periods of intermittent applications of the same load.

Element.

Ductile element. An element capable of sustaining large cyclic deformations beyond the attainment of its strength.

Limited ductile element. An element that is capable of sustaining moderate cyclic deformations beyond the attainment of nominal strength without significant loss of strength.

Nonductile element. An element having a mode of failure that results in an abrupt loss of resistance when the element is deformed beyond the deformation corresponding to the development of its nominal strength. Nonductile elements cannot reliably sustain significant deformation beyond that attained at their nominal strength.

Essential Facilities. Buildings and other structures that are intended to remain operational in the event of extreme environmental loading from flood, wind, snow, or earthquakes.

Factored Load. The product of a nominal load and a load factor.

Flexible Equipment Connections. Those connections between equipment components that permit rotational and/or translational movement without degradation of performance.

Frame.

Braced frame. An essentially vertical truss, or its equivalent, of the concentric or eccentric type that is provided in a building frame system or dual frame system to resist shear.
Concentrically braced frame (CBF). A braced frame in which the members are subjected primarily to axial forces.
Eccentrically braced frame (EBF). A diagonally braced frame in which at least one end of each brace frames into a beam a short distance from a beam-column or from another diagonal brace.
Ordinary concentrically braced frame (OCBF). A steel concentrically braced frame in which members and connections are designed in accordance with the provisions of AISC Seismic without modification.
Special concentrically braced frame (SCBF). A steel or composite steel and concrete concentrically braced frame in which members and connections are designed for ductile behavior.

Frame, Moment.

Intermediate moment frame (IMF). A moment frame in which members and joints are capable of resisting forces by flexure as well as along the axis of the members.
Ordinary moment frame (OMF). A moment frame in which members and joints are capable of resisting forces by flexure as well as along the axis of the members.
Special moment frame (SMF). A moment frame in which members and joints are capable of resisting forces by flexure as well as along the axis of the members.

Frame System.

Building frame system. A structural system with an essentially complete space frame system providing support for vertical loads. Seismic force resistance is provided by shear walls or braced frames.
Dual frame system. A structural system with an essentially complete space frame system providing support for vertical loads. Seismic force resistance is provided by a moment-resisting frame and shear walls or braced frames.
Space frame system. A structural system composed of interconnected members, other than bearing walls, that is capable of supporting vertical loads and that also may provide resistance to seismic forces.

Gravity Load (*W*). The total dead load and applicable portions of other loads.

Hazardous Contents. Material that is highly toxic or potentially explosive and in sufficient quantity to pose a significant life-safety threat to the general public if an uncontrolled release were to occur.

Impact Load. The load resulting from moving machinery, elevators, craneways, vehicles, and other similar forces and kinetic loads, pressure, and possible surcharge from fixed or moving loads.

Importance Factor. A factor assigned to each structure according to its occupancy category in accordance with Table 11.5-1.

Isolation Interface. The boundary between the upper portion of the structure, which is isolated, and the lower portion of the structure, which moves rigidly with the ground.

Isolation System. The collection of structural elements that includes individual isolator units, structural elements that transfer force between elements of the isolation system and connections to other structural elements.

Isolator Unit. A horizontally flexible and vertically stiff structural element of the isolation system that permits large lateral deformations under design seismic load. An isolator unit may be used either as part of or in addition to the weight-supporting system of the building.

Joint. A portion of a column bounded by the highest and lowest surfaces of the other members framing into it.

Limit State. A condition beyond which a structure or member becomes unfit for service and is judged to be no longer useful for its intended function (serviceability limit state) or to be unsafe (strength limit state).

Live Loads. Those loads produced by the use and occupancy of the building or other structure and do not include construction or environmental loads such as wind load, snow load, rain load, earthquake load, flood load, or dead load.

Live Loads (Roof). Those loads produced 1) during maintenance by workers, equipment, and materials; and 2) during the life of the structure by movable objects such as planters and by people.

Load and Resistance Factor Design (LRFD). A method of proportioning structural members and their connections using load and resistance factors such that no applicable limit state is reached when the structure is subjected to appropriate load combinations. The term “LRFD” is used in the design of steel and wood structures.

Load Factor. A factor that accounts for deviations of the actual load from the nominal load, for uncertainties in the analysis that transforms the load into a load effect, and for the probability that more than one extreme load will occur simultaneously.

Loads. Forces or other actions that result from the weight of building materials, occupants and their possessions, environmental effect, differential movement, and restrained dimensional changes. Permanent loads are those loads in which variations over time are rare or of small magnitude. Other loads are variable loads (see also “Nominal loads”).

Loads Effects. Forces and deformations produced in structural members by the applied loads.

Maximum Considered Earthquake. The most severe earthquake effects considered by this code.

Nominal Loads. The magnitudes of the loads specified in this chapter (dead, live, soil, wind, snow, rain, flood, and earthquake.)

Nonbuilding Structure. A structure, other than a building, constructed of a type included in Chapter 15.

P-Delta Effect. The second order effect on shears, axial forces, and moments of frame members induced by axial loads on a laterally displaced building frame.

Panel (Part of a Structure). The section of a floor, wall, or roof located between the supporting frame of two adjacent rows of columns and girders or column bands of floor or roof construction.

Resistance Factor. A factor that accounts for deviations of the actual strength from the nominal strength and the manner and consequences of failure (also called strength reduction factor).

Seismic Design Category. A classification assigned to a structure based on the design spectral response acceleration parameters per Tables 11.6-1 and 11.6-2.

Seismic-force-resisting system. The part of the structural system that has been considered in the design to provide the required resistance to the seismic forces prescribed herein.

Seismic Forces. The assumed forces prescribed herein, related to the response of the structure to earthquake motions, to be used in the design of the structure and its components.

Seismic Response Coefficient. Coefficient C_s, as determined from §12.8.1.1.

Shallow Anchors. Shallow anchors are those with embedment length-to-diameter ratios of less than 8.

Shear Panel. A floor, roof, or wall component sheathed to act as a shear wall or diaphragm.

Shear Wall. A wall designed to resist lateral forces parallel to the plane of the wall.

Site Class. A classification assigned to a site based on the types of soils present and their engineering properties as defined in §11.4.2.

Site Coefficients. The values of F_a and F_v indicated in Tables 11.4-1 and 11.4-2, respectively.

Special Transverse Reinforcement. Reinforcement composed of spirals, closed stirrups, or hoops and supplementary cross-ties provided to restrain the concrete and qualify the portion of the component, where used, as a confined region.

Story Drift Ratio. The story drift divided by the story height.

Strength, Nominal. The capacity of a structure or member to resist the effects of loads, as determined by computations using specified material strengths and dimensions and formulas derived from accepted principles of structural mechanics or by field tests or laboratory tests of scaled models, allowing for modeling effects and differences between laboratory and field conditions.

Strength Design. A method of proportioning structural members such that the computed forces produced in the members by factored loads do not exceed the member design strength (also called load and resistance factor design.) The term “strength design” is used in the design of concrete and masonry structural elements.

Strength Required. Strength of a member, cross section, or connection required to resist factored loads or related internal moments and forces in such combinations as stipulated by these provisions.

Torsional Force Distribution. The distribution of horizontal seismic forces through a rigid diaphragm when the center of mass of the structure at the level under consideration does not coincide with the center of rigidity (sometimes referred to as a diaphragm rotation).

Wall, Load-bearing. Any wall meeting either of the following classifications:

1. Any metal or wood stud wall that supports more than 100 pounds per linear foot (1459 N/m) of vertical load in addition to its own weight.
2. Any masonry or concrete wall that supports more than 200 pounds per linear foot (2919 N/m) of vertical load in addition to its own weight.

Wall, Nonload-bearing. Any wall that is not a load-bearing wall.

Wind-restraint Seismic System. The collection of structural elements that provides restraint of the seismic-isolated-structure for wind loads. The wind-restraint system may be either an integral part of isolator units or a separate device.

Wood Structural Panel. A panel manufactured from veneers; or wood strands or wafers; or a combination of veneer and wood strands or wafers; bonded together with waterproof synthetic resins or other suitable bonding systems.

References

The following codes and standards are referenced in this document. Other reference documents are indicated at the end of each design example.

ACI 318, 2008, American Concrete Institute, *Building Code Requirements for Structural Concrete,* Farmington Hills, Michigan

AISC 360, 2005, American Institute of Steel Construction, *Manual of Steel Construction,* Thirteenth Edition, Chicago, Illinois

AISI Lateral, 2007, American Iron and Steel Institute, *Standard for cold-formed steel framing—Lateral Design*, Washington, D.C.

IBC, 2009, International Code Council, *International Building Code.* Falls Church, Virginia.

MSJC, 2008, *Building Code Requirements for Masonry Structures* (ACI 530-08/ASCE 5-08/TMS 402-08) Washington, D.C.

NDS, 2005, American Forest & Paper Association, *National Design Specification for Wood Construction,* Washington, D.C.

SEAOC Blue Book, 1999, *Recommended Lateral Force Requirements and Commentary.* Structural Engineers Association of California, Sacramento, California.

SDPWS, 2008, American Forest and Paper Association, *Special Design Provisions for Wind and Seismic*, Washington, D.C.