2009 IEBC®

SEAOC STRUCTURAL/SEISMIC DESIGN MANUAL

EXISTING BUILDING SEISMIC HAZARD
REDUCTION DESIGN EXAMPLES

Copyright

Publisher

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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 document, the 2009 *IEBC SEAOC Structural/Seismic Design Manual*, is developed by the Structural Engineers Association of California (SEAOC) with funding provided by SEAOC. Its purpose is to provide guidance on the interpretation and use of the seismic requirements in the 2009 *International Existing Building Code* (IEBC) Appendix A: "Guidelines for the Seismic Retrofit of Existing Buildings," published by the International Code Council, Inc. Furthermore, this document includes where applicable changes in the 2012 IEBC. The design examples make references to these changes and in some cases such changes have been incorporated into the design solution.

The 2009 *IEBC SEAOC Structural/Seismic Design Manual* was developed to fill a void in information that exists between existing buildings and new construction. Because of the complexity posed by existing structures currently, there is no comprehensive document that tackles this issue.

The examples in the 2009 *IEBC SEAOC Structural/Seismic Design Manual* do not necessarily illustrate the only appropriate methods of design and analysis in the field of existing buildings. Proper engineering judgment should always be exercised when applying these examples to real projects. The 2009 *IEBC SEAOC 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 of existing buildings.

SEAOC and ICC intend to update the 2009 *IEBC SEAOC Structural/Seismic Design Manual* with each edition of the building code. The exception is the 2012 IEBC because most of the updates and changes to the 2012 edition have been incorporated herein.

Chris Tokas
Project Manager

Acknowledgments

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The 2009 *IEBC SEAOC Structural/Seismic Design Manual* (SDM) 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 this SDM are:

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Production and Art

The majority of the artwork in the design examples were re-drafted from their original manuscripts by Chris Tokas. Final camera-ready documents were prepared by 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 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:

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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 website at http://www.iccsafe.org. SEAOC, at its sole discretion, may or may not issue written errata

Introduction

This 2009 *IEBC SEAOC Structural/Seismic Design Manual* deals with interpretation and use of the seismic rehabilitation provisions of the Appendix Chapters to the 2009 *International Existing Building Code*® (IEBC). The 2009 *IEBC SEAOC Structural/Seismic Design Manual* is intended to help the reader understand and apply the IEBC 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 deficiencies in existing buildings which form the substance of the provisions of the IEBC Appendix chapters.

The 2009 IEBC including its Appendix chapters reference the 2009 IBC and several national standards for structural design provisions. The primary referenced document is the 2009 IBC, which in turn references the national standards ASCE/SEI 7-05 and ASCE 41-06. These standards establish the loads and analysis procedures. The National Material design standards (such as ACI, AISC, MSJC and NDS) are referenced within the design standards to establish material strengths and element capacities.

The SDM presents various examples with at least one from each individual Appendix Chapter of the 2009 IEBC to illustrate the application of specific seismic hazard reduction provisions of the five Appendix chapters. The examples in each chapter deal primarily with a the seismic hazard reduction of the specific seismic hazard addressed within that chapter. Each example begins with a Forward describing the threat that that seismic vulnerability poses to that class of existing buildings which contain those deficiencies, introduction, the problem to be solved and a statement of given information. The problem is solved through the normal sequence of steps, each of which is illustrated in full. Appropriate code references are sited for each step.

While the 2009 *IEBC SEAOC Structural/Seismic Design Manual* is based on the 2009 IEBC, there are updates in some of the chapters to the provisions of the 2012 IEBC. When portions of the design example are updated to the 2012 IEBC it is brought to attention of the reader.

The 2009 *IEBC 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

The various code application examples are organized by Chapter consistent with the Appendix Chapters of the IEBC. To find an example for a particular provision of the code or rehabilitation procedure, look at the table of contents for the example that best fits your problem requirement.

Generally, the 2009 IEBC, ASCE/SEI 7-05, ACI 318-08 or ASCE 41-06 notation is used throughout. Some other notation is defined in the following pages, or in the examples.

The equations used are those found in common everyday practice and referenced in the IEBC, national design standard or one of the material standards. Where an equation reference is taken from one of these standards the source is identified either in the text preceding the equation or the right hand margin with the standard designation from where that reference equation was taken.

Generally, the examples are presented in the following format. First, there is a statement of the example to be solved, including given information, diagrams, and sketches. This is followed by the "Calculations and Discussion" or "Solution" section, which provides the solution to the example and appropriate discussion to assist the reader. Finally, many of the examples have a third section designated "Conclusions." In this section, comments and discussion on the example and related material are made. Commentary is intended to provide a better understanding of the example and/or to offer guidance to the reader on use of the information generated in the example.

The 2009 *IEBC SEAOC Seismic Design Manual* is based on the 2009 IEBC and the following referenced standards: 2009 IBC, ASCE/SEI 7-05, ASCE 41-06, ACI 318-08, 2005 NDS, or 2005 AISC Steel Construction Manual 13th Edition. When a particular code or standard is referenced then that document is clearly identified within the design example.

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 Section 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, a_b, a_t	=	depth of equivalent rectangular stress block. Subscripts a and b stand for bottom and top of beam cross section respectively
A	=	area of cross section, in.^{2}
A_{brg}	=	bearing area of the head of stud or anchor bolt, in.^{2}, Appendix D, ACI 318
A_c	=	area of column section, in.^{2}
A_g	=	gross area of concrete section, in.^{2}
A_j	=	effective cross-sectional area within a joint in a plane parallel to plane of reinforcement generating shear in the joint, in.^{2}
A_m	=	gross cross-sectional area of main wood member(s), in.^{2}
A_{Nc}	=	projected concrete failure area of a single anchor or group of anchors, for calculation of strength in tension, in.^{2}, see D.5.2.1, Appendix D, ACI 318
A_{Nco}	=	projected concrete failure area of a single anchor, for calculation of strength in tension if not limited by edge distance or spacing, in.^{2}, see D.5.2.1, Appendix D, ACI 318
A_s	=	area of nonprestressed longitudinal tension reinforcement, in.^{2}
A_s	=	sum of gross cross-sectional areas of side member(s), in.^{2}
A_{se}	=	effective cross-sectional area of anchor, in.^{2}, Appendix D, ACI 318
A_{tr}	=	total cross-sectional area of all transverse reinforcement within spacing s that crosses the potential plane of splitting through the reinforcement being developed, in.^{2}, Chapter 12, ACI 318
A_v	=	area of shear reinforcement spacing s, in.^{2}

A_{vc} = projected concrete failure area of a single anchor or group of anchors, for calculation of strength in shear, in.^{2}, see D.6.2.1, Appendix D, ACI 318

A_{Vco} = projected concrete failure area of a single anchor, for calculation of strength in shear, if not limited by corner influences, spacing, or member thickness, in.^{2}, see D.6.2.1, Appendix D, ACI 318

b = width of compression face of member, in.

b_w = web width or diameter of circular section, in.

b_c = cross sectional dimension of column core measured center-to-center of outer legs of the transverse reinforcement, in.

c = distance from the neutral axis of a flexural member to the fiber of maximum compressive strain (in. or mm)

c_{ac} = critical edge distance required to develop the basic concrete breakout strength of a post-installed anchor in uncracked concrete without supplementary reinforcement to control splitting, in., see D.8.6, Appendix D, ACI 318

$c_{a,max}$ = maximum distance from center of an anchor shaft to the edge of concrete, in., Appendix D, ACI 318

$c_{a,min}$ = minimum distance from center of an anchor shaft to the edge of concrete, in., Appendix D, ACI 318

c_{a1} = distance from the center of an anchor shaft to edge of concrete in one direction, in. If shear is applied to anchor, c_{a1} is taken in the direction of the applied shear. If the tension is applied to the anchor, c_{a1} is the minimum edge distance, Appendix D, ACI 318

c_{a2} = distance from center of an anchor shaft to the edge of concrete in the direction perpendicular to c_{a1}, in., Appendix D, ACI 318

c_b = smaller of (a) the distance from center of a bar or wire to nearest concrete surface, and (b) one-half the center-to-center spacing of bars or wires being developed, in., Chapter 12, ACI 318

C_d = deflection amplification factor

C_D = load duration factor

C_{Di} = diaphragm factor for nailed connections

C_F = size factor for sawn lumber

C_{fu} = flat use factor

C_g = group action factor for connections

C_L = beam stability factor

C_m = effective mass factor

C_p = column stability factor

C_s = seismic response coefficient determined in Section 12.8.1.1 ASCE 7 (dimensionless)

C_T = building period coefficient in Section 12.8.2.1, ASCE 7

C_V = volume factor for structural glued laminated timber or structural composite lumber

C_{vx} = vertical distribution factor as determined in Section 12.8.3, ASCE 7

C_0 = modification factor to relate spectral displacement of an equivalent single degree of freedom to the roof displacement of the building multi degree of freedom system

C_1 = modification factor to relate expected maximum inelastic displacements to displacements calculated for linear elastic response

C_2 = modification factor to represent the effects of pinched hysteresis shape, cyclic stiffness degradation and strength deterioration on the maximum displacement response

d = distance from extreme compression fiber to centroid of longitudinal tension reinforcement, in.

D = the effect of dead load

D = in-plane width dimension of pier, inches, or depth of diaphragm, feet (m)

d_b = diameter of reinforcing bar, in.

DCR = demand-capacity ratio specified in Section A111.4.2

d_1, d_2 = cross-sectional dimensions of rectangular compression member in planes of lateral support, in.

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

E_h = effect of horizontal seismic forces as defined in Section 12.14.3.1.1

EI = flexural stiffness of compression member, in.^{2}

E_{min}, E'_{min} = reference and adjusted modulus of elasticity for beam stability and column stability calculations, psi

$(EI)_{min}$, $(EI)'_{min}$ = reference and adjusted EI for beam stability and column stability calculations, psi

E_m = modulus of elasticity of main member, psi

E_s = modulus of elasticity of Side member, psi

E_s = modulus of elasticity of reinforcement and structural steel, psi

E_v = effect of vertical seismic forces as defined in Section 12.14.3.1.2

e'_N = distance between resultant tension load on a group of anchors loaded in tension and the centroid of the group of anchors loaded in tension, in.; e'_N is always positive, Appendix D, ACI 318

e'_v = distance between resultant shear load on a group of anchors loaded in shear in the same direction, and the centroid of the group of anchors loaded in shear in the same direction, in., e'_v is always positive, Appendix D, ACI 318

F_a = short-period site coefficient (at 0.2 s-period); see Section 11.4.3, ASCE 7

F_b, F'_b = reference and adjusted bending design value, psi

F_{bE} = critical buckling design value for bending members, psi

f_c = actual compression stress parallel to grain, psi

F_c, F'_c = reference and adjusted compression design value parallel to grain, psi

F_c* = reference compression design value parallel to grain multiplied by all applicable adjustment factors except C_p, psi

F_{cE} = critical buckling design value for compression members, psi

F_i = the design force applied to Level i

F_i, F_n, F_x = portion of the seismic base shear, V, induced at Level i, n, or x, respectively, as determined in Section 12.8.3

f_l = lateral confining stress

f'_l, f'_{lx}, f'_{ly} = effective lateral confining stress

F_p = the seismic force acting on a component of a structure as determined in Section 13.3.1, ASCE 7

F_{px} = the diaphragm design force

f_s = maximum stress that can be developed in the bar for the straight development, hook development, or lap splice length l_b provided

f_{sp} = tensile-splitting strength of masonry

f_t = actual tension stress parallel to grain, psi

F_v = long-period site coefficient (at 1.0 s-period); see Section 11.4.3, ASCE 7

F_{wx} = force applied to a wall at level x, pounds (N)

f_y = specified yield strength of reinforcement (psi or MPa)

f_{yh} = specified yield strength of the special lateral reinforcement (psi or kPa)

f_{yt} = specified yield strength of transverse reinforcement (psi or MPa)

f'_c = specified compressive strength of concrete used in design

f'_m = compressive strength of masonry

g = acceleration due to gravity

h = height of a shear wall measured as the maximum clear height from top of foundation to bottom of diaphragm framing above, or the maximum clear height from top of diaphragm to bottom of diaphragm framing above

H = least clear height of opening on either side of a pier, inches

h_i, h_n, h_x = the height above the base to Level i, n, or x, respectively

h_{ef} = effective embedment depth of anchor, in., see D.8.5, Appendix D, ACI 318

h/t = height-to-thickness ratio of URM wall. Height, h, is measured between wall anchorage levels and/or slab-on-grade

I = moment of inertia of section about centroidal axis, in.^{4}

I = the importance factor in Section 11.5.1, ASCE 7

I_g = moment of inertia of gross concrete section about centroidal axis, neglecting reinforcement, in.^{4}, ACI 318

k = distribution exponent given in Section 12.8.3, ASCE 7

k_c = coefficient of basic concrete breakout strength in tension, Appendix D

k_{cp} = coefficient for pryout strength, Appendix D

K_e = coefficient modifying lateral confining stress to effective lateral confining stress

K_e = effective lateral stiffness of the building in the direction under consideration

K_i = elastic lateral stiffness of the building in the direction under consideration

KL/r = the lateral slenderness ratio of a compression member measured in terms of its effective length, KL, and the least radius of gyration of the member cross section, r

K_{tr} = transverse reinforcement index, see 12.2.3, Chapter 12, ACI 318

L = overall length of the building (ft or m) at the base in the direction being analyzed

L = span of diaphragm between shear walls. or span between shear wall and open front, feet (m)

L = design live load

l_b = existing development length of reinforcement provided

L_c = length of crosswall, feet (m)

l_d = development length in tension of deformed bar, deformed wire, plain and deformed welded wire reinforcement, or pretensioned strand, in., ACI 318

l_{dh} = development length in tension of deformed bar or deformed wire with a standard hook, measured from critical section to outside end of hook (straight embedment length between critical section and start of hook [point of tangency] plus inside radius of bend and one bar diameter), in. ACI 318

l_e = effective span length of bending member, in.

$l_{e/d}$ = slenderness ratio of compression member

l_{e1}, l_{e2} = effective length of compression member in planes of lateral support, in.

L_i = effective span for an open-front building specified in Section A111.8, feet (m)

l_n = length of clear span measured face-to-face of supports, in.

L_p = length of plastic hinge zone, in.

L_r = roof live load

m = component demand modification factor to account for expected ductility associated with this action at the selected structural performance level

M = bending moment at cross section

M_{bot} = nominal positive beam moment capacity based on bottom reinforcement

M_n = nominal flexural strength at section

M_{pr} = probable flexural strength of members, with or without axial load, determined using the properties of the member at the joint faces assuming a tensile stress in tile longitudinal bars of at least $1.25f_y$ and a strength reduction factor, ϕ, of 1.0, in.-lb

M_{top} = nominal negative beam moment capacity based on top reinforcement

M_u = factored moment at section in.-lb

M_y = yield moment at cross section

n = designation for the level that is uppermost in the main portion of the building

n = number of fasteners in a row

N_b = basic concrete breakout strength in tension of a single anchor in cracked concrete, lb, see D.5.2.2, Appendix D, ACI 318

N_{cb} = nominal concrete breakout strength in tension of a single anchor, lb, see D.5.2.1, Appendix D, ACI 318

N_{cbg} = nominal concrete breakout strength in tension of a group of anchors. lb. see D5.2.1. Appendix D, ACI 318

N_n = nominal strength in tension

N_{sa} = nominal strength of a single anchor or group of anchors in tension as governed by the steel strength, lb, see D.5.1.1 and D.5.1.2, Appendix D, ACI 318

N_u = factored axial load normal to cross section occurring simultaneously with Vu or Tu to be taken as positive for compression and negative for tension, lb

P	=	applied force as determined by standard test method of ASTM C 496 or ASTM E 519, pounds (N)
P	=	total concentrated load or total axial load, lbs
P_D	=	superimposed dead load at the location under consideration, pounds (kN). For determination of the rocking shear capacity, dead load at the top of the pier under consideration shall be used
P_{D+L}	=	press resulting from the dead plus actual live load in place at the time of testing, pounds per square inch (kPa)
P_u	=	factored axial load on column
P_w	=	weight of wall, pounds (N)
Q_D	=	design action due to dead load
Q_E	=	effect of horizontal seismic (earthquake-induced) Forces
Q_G	=	design action due to gravity load
Q_L	=	design action due to live load
R	=	response modification coefficient as given in Tables 12.2-1, ASCE 7
R	=	ratio of the elastic strength demand to the yield strength coefficient
r	=	radius of gyration, in.
R_B	=	slenderness ratio of bending member
$R_{\max}$	=	maximum strength ratio
s	=	center-to-center spacing of items, such as longitudinal reinforcement, transverse reinforcement, prestressing tendons, wires, or anchors
S_1	=	mapped MCE, 5 percent damped, spectral response acceleration parameter at a period of 1 s as defined in Section 11.4.1, ASCE 7
S_a	=	response spectral acceleration at the effective fundamental period in the direction under consideration
S_{DS}	=	design, 5 percent damped, spectral response acceleration parameter at short periods as defined in Section 11.4.4, ASCE 7
S_{D1}	=	design, 5 percent damped, spectral response acceleration parameter at a period of 1 s as defined in Section 11.4.4, ASCE 7

S_{MS} = the MCE, 5 percent damped, spectral response acceleration at short periods adjusted for site class effects as defined in Section 11.4.3, ASCE 7

S_{M1} = the MCE, 5 percent damped, spectral response acceleration at a period of 1 s adjusted for site class effects as defined in Section 11.4.3, ASCE 7

s_h = spacing of special lateral reinforcement (in. or mm)

S_S = mapped MCE, 5 percent damped, spectral response acceleration parameter at short periods as defined in Section 11.4.1, ASCE 7

S_x = section modulus about the major of *x-x* axis

S_y = section modulus about the minor of *y-y* axis

T = the fundamental period of the building

T_a = approximate fundamental period of the building as determined in Section 12.8.2, ASCE 7

T_e = effective fundamental period of the building

T_i = elastic fundamental period in the direction under consideration calculated by elastic dynamic analysis

T_L = long-period transition period as defined in Section 11.4.5, ASCE 7

T_0 = $0.2S_{D1}/S_{DS}$

T_S = S_{D1}/S_{DS}

V = total design lateral force or shear at the base

V = shear at cross section

V_a = the shear strength of any URM pier or wall, pounds (N)

V_b = basic concrete breakout strength in shear of a single anchor in cracked concrete, lb, see D.6.2.2 and D.6.2.3, Appendix D, ACI 318

V_c = nominal shear strength provided by concrete, lb

V_c = average column shear

V_{ca} = total shear capacity of crosswalls in the direction of analysis immediately above the diaphragm level being investigated, $v_c L_c$, pounds (N)

V_{cb} = nominal concrete breakout strength in shear of a single anchor, lb, see D.6.2.1, Appendix D, ACI 318

V_{cb} = total shear capacity of cross walls in the direction of analysis immediately below the diaphragm level being investigated, $\nu_c L_c$, pounds (N)

V_{cbg} = nominal concrete breakout strength in shear of a group of anchors, lb, see D.6.2.1, Appendix D

V_{cp} = nominal concrete pryout strength of a single anchor, lb, see D.6.3, Appendix D, ACI 318

V_{cpg} = nominal concrete pryout strength of a group of anchors, lb, see D.6.3, Appendix D, ACI 318

V_j = total story shear force at level *j*.

V_n = nominal shear strength of concrete lb

V_e = design shear force corresponding to the development of the probable moment strength of the member

V_n = nominal shear strength

V_p = shear force assigned to a pier on the basis of its relative shear rigidity, pounds (N)

V_r = pier rocking shear capacity of any URM wall or wall pier, pounds (N)

V_s = nominal shear strength provided by shear reinforcement, lb

V_{sa} = nominal strength in shear of a single anchor or group of anchors as governed by the steel strength, lb, see D.6.1.1 and D.6.1.2, Appendix D, ACI 318

V_{test} = load at incipient cracking for each in-place shear test per UBC Standard 21-6, pounds (kN)

V_u = factored shear force at section lb

V_{wx} = total shear force resisted by a shear wall at the level under consideration, pounds (N)

V_y = yield strength of the building in the direction under consideration

W = total seismic dead load as defined in the building code, pounds (N)

W = effective seismic weight of the building as defined in Section 12.7.2, ASCE 7

W_d = total dead load tributary to a diaphragm level, pounds (N)

w_g = gravity load on beam

w_i = the weight tributary to Level *i*

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

W_w = total dead load of a URM wall above the level under consideration or above an open-front building, pounds (N)

W_{wx} = dead load of a URM wall assigned to level *x* halfway above and below the level under consideration, pounds (N)

Z, Z' = reference and adjusted lateral design value for a single fastener connection, lbs

Z_{II} = reference lateral design value for a single dowel-type fastener connection with all wood members loaded parallel to grain, lbs

α_1 = positive post yield slope ratio equal to the positive post yield stiffness divided by the effective stiffness

α_2 = negative post yield slope ratio equal to the negative post yield stiffness divided by the effective stiffness

α_e = effective negative post yield slope ratio

$\alpha_{P\text{-}\Delta}$ = negative slope ratio caused by P-Δ effects

δ_t = target displacement

Δ_d = lesser of target displacement or displacement at maximum base shear

Δ_y = displacement at effective yield strength

ε_{cu} = ultimate compressive strain in concrete

ε_{su} = ultimate steel strain

ϕ = Strength reduction factor

ϕ_i = modal displacement of floor

ϕ_y = yield curvature at cross section

ϕ_u = ultimate curvature at cross section

λ = modification factor related to unit weight of concrete

λ = near field factor

ν_a = the shear strength of any URM pier, pounds (N)

ν_c = unit shear capacity value for a crosswall sheathed with any of the materials given in Table A1-D or A1-E, pounds per foot (N/m)

ν_m	=	shear strength of unreinforced masonry, pounds per square inch (kPa)
ν_j^{avg}	=	average shear stress in concrete columns
ν_t	=	mortar shear strength as specified in Section AI06.3.3.5, pounds per square inch (kPa)
ν_{to}	=	mortar shear test values as specified in Section A106.3.3.5, pounds per square inch (kPa)
ν_u	=	unit shear capacity value for a diaphragm sheathed with any of the materials given in Table A1-D or A1-E, pounds per foot (N/m)
ρ	=	a redundancy factor based on the extent of structural redundancy present in a building as defined in Section 12.3.4, ASCE 7
ρ, ρ_x, ρ_y	=	ratio of A_s to $b_w d$
ρ_{cc}	=	ratio of longitudinal area of steel to confined core section
Ω_0	=	overstrength factor as defined in Tables 12.2-1
$\psi_{c,N}$	=	factor used to modify tensile strength of anchors based on presence or absence of cracks in concrete, see D.5.2.6, Appendix D, ACI 318
$\psi_{c,P}$	=	factor used to modify pullout strength of anchors based on presence or absence of cracks in concrete, see D.5.3.6, Appendix D, ACI 318
$\psi_{c,V}$	=	factor used to modify shear strength of anchors based on presence or absence of cracks in concrete and presence and absence of supplementary reinforcement, see D.6.2.7, for anchors in shear, Appendix D, ACI 318
$\psi_{cp,N}$	=	factor used to modify tensile strength of post installed anchors intended for use in uncracked concrete without supplementary reinforcement, see D.5.2.7, Appendix D, ACI 318
ψ_e	=	factor used to modify development length based on reinforcement coating, see 12.2.4, Chapter 12, ACI 318
$\psi_{ec,N}$	=	factor used to modify tensile strength of anchors based on eccentricity of applied loads, see D.5.2.4, Appendix D, ACI 318
$\psi_{ec,V}$	=	factor used to modify shear strength of anchors based on eccentricity of applied loads, see D.6.2.5, Appendix D, ACI 318
$\psi_{ed,N}$	=	factor used to modify tensile strength of anchors based on proximity to edges of concrete member, see D.5.2.5, Appendix D, ACI 318
$\psi_{ed,V}$	=	factor used to modify shear strength of anchors based on proximity to edges of concrete member, see D.6.2.6, Appendix D, ACI 318

ψ_s = factor used to modify development length based on reinforcement size, see 12.2.4, Chapter 12, ACI 318

ψ_t = factor used to modify development length based on reinforcement location, see 12.2.4, Chapter 12, ACI 318

$\sum M_b$ = sum of moment capacity of the beams at a joint

$\sum M_c$ = sum of moment capacity of the columns at a joint

$\sum v_u D$ = sum of diaphragm shear capacities of both ends of the diaphragm, pounds (N)

$\sum\sum v_u D$ = for diaphragms coupled with crosswalls, $v_u D$ includes the sum of shear capacities of both ends of diaphragms coupled at and above the level under consideration, pounds (N)

$\sum W_d$ = total dead load of all the diaphragms at and above the level under consideration, pounds (N)

θ_p = plastic rotation in radians

Definitions

Acceptance Criteria: Limiting values of properties such as drift, strength demand, and inelastic deformation used to determine the acceptability of a component at a given performance level.

Action: An internal moment, shear, torque, axial load, deformation, displacement, or rotation corresponding to a displacement due to a structural degree of freedom; designated as force- or deformation-controlled.

Active Fault: A fault for which there is an average historic slip rate of 1 mm per year or more, and evidence of seismic activity within Holocene times (past 11,000 years).

Adjusted Resistance: The reference resistance adjusted to include the effects of applicable adjustment factors resulting from end use and other modifying factors excluding time-effect adjustments, which are considered separately and are not included.

Apartment House: Any building or portion thereof that contains three or more dwelling units. For the purposes of this chapter, "apartment house" includes residential condominiums.

Aspect Ratio: The span-width ratio for horizontal diaphragms and the height-length ratio for vertical diaphragms.

Assembly: Two or more interconnected components.

Authority Having Jurisdiction: The organization, political subdivision, office, or individual legally charged with responsibility for administering and enforcing the provisions of this standard.

Balloon Framing: Continuous stud framing from sill to roof, with intervening floor joists nailed to studs and supported by a let-in ribbon.

Base: The level at which earthquake effects are imparted to the building.

Beam: A structural member whose primary function is to carry loads transverse to its longitudinal axis.

Bearing Wall: A wall that supports gravity loads of at least 200 lbs/lineal ft from floors and/or roofs.

Bed Joint: The horizontal layer of mortar on which a masonry unit is laid.

Boundary Component: A structural component at the boundary of a shear wall or a diaphragm or at an edge of an opening in a shear wall or a diaphragm that possesses tensile and/or compressive strength to transfer lateral forces to the lateral-force-resisting system.

Braced Frame: A vertical lateral-force-resisting element consisting of vertical, horizontal, and diagonal components joined by concentric or eccentric connections.

BSE-1: Basic Safety Earthquake-1, taken as the lesser of the ground shaking for a 10%/50-year earthquake or two-thirds of the BSE-2 at a site.

BSE-2: Basic Safety Earthquake-2, taken as the ground shaking based on the Maximum Considered Earthquake (MCE) at a site.

BSO: Basic Safety Objective is a Rehabilitation Objective that achieves the dual rehabilitation goals of the Life Safety Building Performance Level for the BSE-1 Earthquake Hazard Level and the Collapse Prevention Building Performance Level for the BSE-2 Earthquake Hazard Level.

Building Code: The code currently adopted by the jurisdiction for new buildings.

Building Occupancy: The purpose for which a building, or part thereof, is used or intended to be used, designated in accordance with the applicable building code.

Building Performance Level: A limiting damage state for a building, considering structural and nonstructural components, used in the definition of Rehabilitation Objectives.

Cavity Wall: A masonry wall with an air space between wythes.

Chemical Anchor: An assembly consisting of a threaded rod, washer, nut and chemical adhesive approved by the building official for installation in existing concrete or masonry.

Chord: See **Diaphragm Chord**.

Clay Tile Masonry: Masonry constructed with hollow units made of clay tile.

Clay-Unit Masonry: Masonry constructed with solid, cored, or hollow units made of clay; can be ungrouted or grouted.

Closed Stirrups or Ties: Transverse reinforcement defined in Chapter 7 of ACI 318 consisting of standard stirrups or ties with 90-degree hooks and lap splices in a pattern that encloses longitudinal reinforcement.

Code Official: The individual representing a local jurisdiction who is legally charged with responsibility for administering and enforcing the provisions of a legally adopted building code.

Coefficient of Variation: For a sample of data, the ratio of the standard deviation for the sample to the mean value for the sample.

Collar Joint: The vertical space between adjacent wythes. A collar joint may contain mortar or grout.

Collector: See **Drag Strut**.

Column (or Beam) Jacketing: A rehabilitation method in which a concrete column or beam is encased in a steel or concrete "jacket" to strengthen and/or repair the member by confining the concrete.

Component, Primary: A structural component that is required to resist seismic forces in order for the structure to achieve the selected performance level.

Component, Rigid: A component, including its attachments, having a fundamental period less than or equal to 0.06 sec.

Component, Secondary: A structural component that is not required to resist seismic forces in order for the structure to achieve the selected performance level.

Component, Structural: A component of a building that provides gravity- or lateral-load resistance as part of a continuous load path to the foundation, including beams, columns, slabs, braces, walls, wall piers, coupling beams, and connections; designated as primary or secondary.

Composite Masonry Wall: Multi-wythe masonry wall acting with composite action.

Composite Panel: A wood structural panel product composed of a combination of wood veneer and wood-based material, and bonded with waterproof adhesive.

Concentric Braced Frame: Braced frame element in which component worklines intersect at a single point or at multiple points such that the distance between intersecting worklines (or eccentricity) is less than or equal to the width of the smallest component connected at the joint.

Concrete Masonry: Masonry constructed with solid or hollow units made of concrete; can be ungrouted or grouted.

Condition of Service: The environment to which the structure will be subjected.

Congregate Residence: A congregate residence is any building or portion thereof for occupancy by other than a family that contains facilities for living, sleeping and sanitation as required by the building code and that may include facilities for eating and cooking. A congregate residence may be a shelter, convent, monastery, dormitory, fraternity or sorority house, but does not include jails, hospitals, nursing homes, hotels or lodging houses.

Connection: A link that transmits actions from one component or element to another component or element, categorized by type of action (moment, shear, or axial).

Connection Hardware: Proprietary or custom-fabricated body of a component that is used to link wood components.

Connectors: Nails, screws, lags, bolts, split rings, shear plates, headed studs, and welds used to link components to other components.

Control Node: A node located at the center of mass at the roof of a building used in the Nonlinear Static Procedure (NSP) to measure the effects of earthquake shaking on a building.

Corrective Measure: Any modification of a component or element, or the structure as a whole, implemented to improve building performance.

Coupling Beam: A component that ties or couples adjacent shear walls acting in the same plane.

Cripple Studs: Short studs between a header and top plate at openings in wall framing, or studs between the base and sill of an opening.

Cripple Wall: A wood-frame stud wall extending from the top of the foundation to the underside of the lowest floor framing.

Critical Action: The component action that reaches its elastic limit at the lowest level of lateral deflection or loading of the structure.

Cross Tie: A component that spans the width of the diaphragm and delivers out-of-plane wall forces over the full depth of the diaphragm.

Crosswall: A new or existing wall that meets the requirements of Section A 111.3 and the definition of Section A111.3 of the IEBC. A cross wall is not a shear wall.

Crosswall Shear Capacity: The unit shear value times the length of the crosswall, $v_c L_c$

Decay: Decomposition of wood caused by action of wood-destroying fungi. The term "dry rot" is used interchangeably with decay.

Decking: Solid sawn lumber or glue-laminated decking, nominally 2 to 4 in. thick and 4 or more in. wide. Decking shall be tongue-and-groove or connected at longitudinal joints with nails or metal clips.

Deep Foundation: Driven piles made of steel, concrete, or wood, or cast-in-place concrete piers or drilled shafts of concrete.

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

Demand: The amount of force or deformation imposed on an element or component.

Design Displacement: The design earthquake displacement of an isolation or energy dissipation system, or elements thereof, excluding additional displacement due to actual and accidental torsion.

Design Earthquake: A user-specified earthquake for the design of a building having ground shaking criteria described in the building code.

Design Resistance (Force or Moment, as appropriate): Resistance provided by member or connection; the product of adjusted resistance, the resistance factor, and time-effect factor.

Diagonal Bracing: Inclined components designed to carry axial load, enabling a structural frame to act as a truss to resist lateral forces.

Diaphragm: A horizontal (or nearly horizontal) structural element used to transfer inertial lateral forces to vertical elements of the lateral-force-resisting system.

Diaphragm Chord: A boundary component perpendicular to the applied load that is provided to resist tension or compression due to the diaphragm moment.

Diaphragm Collector: A component parallel to the applied load that is provided to transfer lateral forces in the diaphragm to vertical elements of the lateral-force-resisting system.

Diaphragm Edge: The intersection of the horizontal diaphragm and a shear wall.

Diaphragm Ratio: See **Aspect Ratio**.

Diaphragm Shear Capacity: The unit shear value times the depth of the diaphragm, $v_u D$.

Diaphragm Strut: See **Diaphragm Tie**.

Diaphragm Tie: A component parallel to the applied load that is provided to transfer wall anchorage or diaphragm inertial forces within or across the diaphragm. Also called diaphragm strut.

Dimensioned Lumber: Lumber from nominal 2 through 4 inches thick and nominal 2 or more inches wide.

Displacement Restraint System: Collection of structural components and elements that limit lateral displacement of seismically-isolated buildings during the BSE-2.

Dowel-Bearing Strength: The maximum compression strength of wood or wood-based products when subjected to bearing by a steel dowel or bolt of specific diameter.

Dowel-Type Fasteners: Bolts, lag screws, wood screws, nails, and spikes.

Dressed Size: The dimensions of lumber after surfacing with a planing machine.

Dry Rot: See **Decay**.

Dry Service: Structures wherein the maximum equilibrium moisture content does not exceed 19%.

Dwelling Unit: Any building or portion thereof for not more than one family that contains living facilities, including provisions for sleeping, eating, cooking and sanitation as required by the building code or congregate residence for 10 or fewer persons.

Earthquake Hazard Level: Ground shaking demands of specified severity, developed on either a probabilistic or deterministic basis.

Edge Distance: The distance from the edge of the member to the center of the nearest fastener.

Effective Damping: The value of equivalent viscous damping corresponding to the energy dissipated by the building, or element thereof, during a cycle of response.

Effective Stiffness: The value of the lateral force in the building, or an element thereof, divided by the corresponding lateral displacement.

Effective Void Ratio: Ratio of collar joint area without mortar to the total area of the collar joint.

Element: An assembly of structural components that act together in resisting forces, including gravity frames, moment-resisting frames, braced frames, shear walls, and diaphragms.

Expansion Anchor: An approved mechanical fastener placed in hardened concrete that is designed to expand in a self-drilled or pre-drilled hole of a specified size and engage the sides of the hole in one or more locations to develop shear and/or tension resistance to applied loads without grout, adhesive or drypack.

Expansion Bolt: A single assembly approved by the building official for installation in existing concrete or masonry. For the purpose of this chapter, expansion bolts shall contain a base designed to expand when properly set, wedging the bolt in the pre-drilled hole. Assembly shall also include appropriate washer and nut.

Expected Strength: The mean value of resistance of a component at the deformation level anticipated for a population of similar components, including consideration of the variability in material strength as wells as strain-hardening and plastic section development

Fair Condition: Masonry found during condition assessment to have mortar and units intact but with minor cracking.

Fault: Plane or zone along which earth materials on opposite sides have moved differentially in response to tectonic forces.

Flexible Connection: A link between components that permits rotational and/or translational movement without degradation of performance, including universal joints, bellows expansion joints, and flexible metal hose.

Flexible Diaphragm: A diaphragm with horizontal deformation along its length more than twice the average story drift.

Flexible Diaphragms: Roofs and floors including, but not limited to, those sheathed with plywood, wood decking (1-by or 2-by) or metal decks without concrete topping slabs.

Foundation System: An assembly of structural components, located at the soil–structure interface, that transfer loads from the superstructure into the supporting soil.

Fundamental Period: The longest natural period of the building in the direction under consideration.

Gauge or Row Spacing: The center-to-center distance between fastener rows or gauge lines.

Glulam Beam: Shortened term for glue-laminated beam, which is a wood-based component made up of layers of wood bonded with adhesive.

Good Condition: Masonry found during condition assessment to have mortar and units intact and no visible cracking.

Grade: The classification of lumber with regard to strength and utility, in accordance with the grading rules of an approved agency.

Grading Rules: Systematic and standardized criteria for rating the quality of wood products.

Ground Floor: Any floor whose elevation is immediately accessible from an adjacent grade by vehicles or pedestrians. The ground floor portion of the structure does not include any floor that is completely below adjacent grades.

Guestroom: Any room or rooms used or intended to be used by a guest for sleeping purposes. Every 100 square feet (9.3 m^2) of superficial floor area in a congregate residence shall be considered a guestroom.

Gypsum Wallboard or Drywall: An interior wall surface sheathing material; can sometimes be considered for resisting lateral forces.

Head Joint: Vertical mortar joint placed between masonry units in the same wythe.

Hollow Masonry Unit: A masonry unit with net cross-sectional area in every plane parallel to the bearing surface less than 75% of the gross cross-sectional area in the same plane.

Hoops: Transverse reinforcement defined in Chapter 21 of ACI 318 consisting of closed ties with 135-degree hooks embedded into the core and no lap splices.

Hotel: Any building containing six or more guestrooms intended or designed to be used, rented, hired out to be occupied, or that are occupied, for sleeping purposes by guests.

Infill: A panel of masonry placed within a steel or concrete frame. Panels separated from the surrounding frame by a gap are termed "isolated infills." Panels that are in full contact with a frame around its full perimeter are termed "shear infills."

In-Plane Wall: See **Shear Wall**.

International Building Code: The 2009 *International Building Code* (IBC).

Joint: An area where ends, surfaces, or edges of two or more components are attached; categorized by type of fastener or weld used and method of force transfer.

King Stud: Full-height studs adjacent to openings that provide out-of-plane stability to cripple studs at openings.

Knee Joint: A joint that in the direction of framing has one column and one beam.

Landslide: A down-slope mass movement of earth resulting from any cause.

Lateral-Force-Resisting System: Those elements of the structure that provide its basic lateral strength and stiffness.

Life Safety Performance Level: The building performance level that includes significant damage to both structural and nonstructural components during a design earthquake, though at least some margin against either partial or total structural collapse remains. Injuries may occur, but the level of risk for life-threatening injury and entrapment is low.

Light Framing: Repetitive framing with small, uniformly spaced members.

Lightweight Concrete: Structural concrete that has an air-dry unit weight not exceeding 115pcf.

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

Load and Resistance Factor Design: A method of proportioning structural components (members, connectors, connections, and assemblages) using load factors and strength reduction factors such that no applicable limit state is exceeded when the structure is subjected to all design load combinations.

Load Duration: The period of continuous application of a given load, or the cumulative period of intermittent applications of load. See **Time-Effect Factor**.

Load Path: A path through which seismic forces are delivered from the point at which inertial forces are generated in the structure to the foundation and, ultimately, the supporting soil.

Load Sharing: The load redistribution mechanism among parallel components constrained to deflect together.

Load/Slip Constant: The ratio of the applied load to a connection and the resulting lateral deformation of the connection in the direction of the applied load.

Lodging House: Any building or portion thereof containing at least one but not more than five guest rooms where rent is paid in money, goods, labor or otherwise.

Lower-Bound Strength: The mean minus one standard deviation of the yield strengths, Q_y, for a population of similar components.

Lumber: The product of the sawmill and planing mill, usually not further manufactured other than by sawing, resawing, passing lengthwise through a standard planing machine, crosscutting to length, and matching.

Masonry: The assemblage of masonry units, mortar, and possibly grout and/or reinforcement; classified with respect to the type of masonry unit, including clay-unit masonry, concrete masonry, or hollow-clay tile masonry.

Maximum Considered Earthquake (MCE): An extreme earthquake hazard level defined by MCE maps which are based on a combination of mean 2%/50-year probabilistic spectra and 150% of median deterministic spectra at a given site.

Mean Return Period: The average period of time, in years, between the expected occurrences of an earthquake of specified severity.

Model Building Type: One of the common building types listed and described in Table 10-2 of ASCE 41-06.

Moisture Content: The weight of the water in wood expressed as a percentage of the weight of the oven-dried wood.

Moment Frame: A building frame system in which seismic shear forces are resisted by shear and flexure in members and joints of the frame.

Multiunit Residential Buildings: Hotels, lodging houses, congregate residences and apartment houses.

Narrow Wood Shear Wall: Wood shear walls with an aspect ratio (height-to-width) greater than 2:1.

Nominal Size: The approximate rough-sawn commercial size by which lumber products are known and sold in the market. Actual rough-sawn sizes vary from nominal. Reference to standards or grade rules is required to determine nominal to actual finished size relationships, which have changed over time.

Nominal Strength: The capacity of a structure or component to resist the effects of loads, as determined by (1) computations using specified material strengths and dimensions, and formulas derived from accepted principles of structural mechanics; or (2) field tests or laboratory tests of scaled models, allowing for modeling effects and differences between laboratory and field conditions.

Nonbearing Wall: A wall that supports gravity loads less than 200 lbs/lineal ft.

Nonconforming Structural Materials: Wall bracing materials other than wood structural panels or diagonal sheathing.

Normal Wall: A wall perpendicular to the direction of seismic forces.

Open-Front Wall Line: An exterior wall line, without vertical elements of the lateral-force-resisting system in one or more stories, that requires tributary seismic forces to be resisted by diaphragm rotation or excessive cantilever beyond parallel lines of shear walls. Diaphragms that cantilever more than 25 percent of the distance between lines of lateral-force-resisting elements from which the diaphragm cantilevers shall be considered excessive.

Exterior exit balconies of 6 feet (1,829 mm) or less in width shall not be considered excessive cantilevers.

Oriented Strand Board (OSB): A mat-formed wood structural panel product composed of thin rectangular wood strands or wafers with surface layers arranged in the long panel direction and core layers arranged in the cross-panel direction and bonded with waterproof adhesive.

Out-of-Plane Wall: A wall that resists lateral forces applied normal to its plane.

Overturning: Behavior that results when the moment produced at the base of vertical lateral-force-resisting elements is larger than the resistance provided by the building weight and the foundation resistance to uplift.

Panel: A sheet-type wood product.

Panel Rigidity or Stiffness: The in-plane shear rigidity of a panel; the product of panel thickness and modulus of rigidity.

Panel Shear: Shear stress acting through the panel thickness.

Parapet: Portions of a wall extending above the roof diaphragm.

Partially Grouted Masonry Wall: A masonry wall containing grout in some of the cells.

Particleboard: A panel manufactured from small pieces of wood, hemp, and flax, bonded with synthetic or organic binders, and pressed into flat sheets.

Perforated Wall or Infill Panel: A wall or panel not meeting the requirements for a solid wall or infill panel.

Perimeter Foundation: A foundation system that is located under the exterior walls of a building.

Pitch or Spacing: The longitudinal center-to-center distance between any two consecutive holes or fasteners in a row.

Platform Framing: Construction method in which stud walls are constructed one floor at a time, with a floor or roof joist bearing on top of the wall framing at each level.

Ply: A single sheet of veneer, or several strips laid with adjoining edges that form one veneer lamina in a glued plywood panel.

Plywood: A wood structural panel product composed of sheets of wood veneer bonded with adhesive cured upon application of heat and pressure with the grain of adjacent layers oriented at right angles to one another.

Pointing: The partial reconstruction of the bed joints of an unreinforced masonry wall as defined in UBC Standard 21-8.

Poor Condition: Masonry found during condition assessment to have degraded mortar, degraded masonry units, or significant cracking.

Preservative: A chemical that, when suitably applied to wood, makes the wood resistant to attack by fungi, insects, marine borers, or weather conditions.

Pressure-Preservative-Treated Wood: Wood products pressure-treated by an approved process and preservative.

Primary Component: See **Component, Primary**.

Primary (Strong) Panel Axis: The direction that coincides with the length of the panel.

Probability of Exceedance: The chance, expressed as a percentage (%), that a more severe event will occur within a specified period, expressed in number of years.

P-Δ Effect: The secondary effect of vertical loads and lateral deflection on the shears and moments in various components of a structure.

Redundancy: The quality of having alternative load paths in a structure by which lateral forces can be transferred, allowing the structure to remain stable following the failure of any single element.

Re-Entrant Corner: Plan irregularity in a diaphragm, such as an extending wing, plan inset, or E-, T-, X-, or L-shaped configuration, where large tensile and compressive forces can develop.

Rehabilitation Measures: Modifications to existing components, or installation of new components, that correct deficiencies identified in a seismic evaluation as part of a scheme to rehabilitate a building to achieve a selected Rehabilitation Objective.

Rehabilitation Method: One or more procedures and strategies for improving the seismic performance of existing buildings.

Rehabilitation Objective: One or more rehabilitation goals, each goal consisting of the selection of a target Building Performance Level and an Earthquake Hazard Level.

Rehabilitation Strategy: A technical approach for developing rehabilitation measures for a building to improve seismic performance.

Reinforced Masonry Wall: A masonry wall with the following minimum amounts of vertical and horizontal reinforcement: vertical reinforcement of at least 0.20 $in.^2$ in cross section at each corner or end, at each side of each opening, and at a maximum spacing of 4 ft throughout. Horizontal reinforcement of at least 0.20 $in.^2$ in cross section at the top of the wall, at the top and bottom of wall openings, at structurally connected roof and floor openings, and at a maximum spacing of 10 ft.

Repointing: A method of repairing cracked or deteriorating mortar joints in which the damaged or deteriorated mortar is removed and the joints are refilled with new mortar.

Required Member Resistance (or Required Strength): Action on a component or connection, determined by structural analysis, resulting from the factored loads and the critical load combinations.

Resistance: The capacity of a structure, component, or connection to resist the effects of loads.

Resistance Factor: A reduction factor applied to member resistance that accounts for unavoidable deviations of the actual strength from the nominal value and for the manner and consequences of failure.

Retrofit: An improvement of the lateral-force-resisting system by *alteration* of existing structural elements or *addition* of new structural elements.

Rigid Diaphragm: A diaphragm with horizontal deformation along its length less than half the average story drift at the ends. Usually rigid diaphragms are of reinforced concrete construction supported by concrete beams and columns or by structural steel beams and columns.

Rough Lumber: Lumber as it comes from the saw prior to any dressing operation.

Row of Fasteners: Two or more fasteners aligned with the direction of load.

Running Bond: A pattern of masonry where the head joints are staggered between adjacent courses by at least one-quarter of the length of a masonry unit.

Secondary Component: See **Component, Secondary**.

Seismic Evaluation: An approved process or methodology of evaluating deficiencies in a building which prevent the building from achieving a selected Rehabilitation Objective.

Shallow Foundation: Isolated or continuous-spread footings or mats.

Shear Wall: A wall that resists lateral forces applied parallel with its plane. Also known as an in-plane wall.

Sheathing: Lumber or panel products that are attached to parallel framing members, typically forming wall, floor, ceiling, or roof surfaces.

Short Captive Column: A column with a height-to-depth ratio less than 75% of the nominal height-to-depth ratios of the typical columns at that level.

Shrinkage: Reduction in the dimensions of wood due to a decrease of moisture content.

Simplified NSP Analysis: A nonlinear static analysis in which only primary lateral-force-resisting elements are modeled, and component degradation is not explicitly modeled.

Slip-Critical Joint: A bolted joint in which slip resistance of the connection is required.

Snug-Tight: As tight as an individual can torque a nut on a bolt by hand, using a wrench with a 10-inch-long (254 mm) handle, and the point at which the full surface of the plate washer is contacting the wood member and slightly indenting the wood surface.

Soft Wall Line: A wall line whose lateral stiffness is less than that required by story drift limitations or deformation compatibility requirements of this chapter. In lieu of analysis, a soft wall line may be defined as a wall line in a story where the story stiffness is less than 70 percent of the story above for the direction under consideration.

Solid Masonry Unit: A masonry unit with net cross-sectional area in every plane parallel to the bearing surface equal to 75% or more of the gross cross-sectional area in the same plane.

Solid Wall or Solid Infill Panel: A wall or infill panel with openings not exceeding 5% of the wall surface area. The maximum length or height of an opening in a solid wall must not exceed 10% of the wall width or story height. Openings in a solid wall or infill panel must be located within the middle 50% of a wall length and story height, and must not be contiguous with adjacent openings.

Stack Bond: A placement of masonry units such that the head joints in successive courses are aligned vertically.

Stiff Diaphragm: A diaphragm that is neither flexible nor rigid.

Story: The portion of a structure between the tops of two successive finished floor surfaces and, for the top-most story, from the top of the floor finish to the top of the roof structural element and includes any basement or underfloor space of a building with cripple walls exceeding 4 feet (1,219 mm) in height.

Story Strength: The total strength of all seismic resisting elements sharing the same Story shear in the direction under consideration.

Strength: The maximum axial force, shear force, or moment that can be resisted by a component.

Stress Resultant: The net axial force, shear, or bending moment imposed on a cross section of a structural component.

Strong-Back System: A secondary system, such as a frame, commonly used to provide out-of-plane support for an unreinforced or under-reinforced masonry wall.

Strong Column–Weak Beam: A connection where the capacity of the column in any moment frame joint is greater than that of the beams, ensuring inelastic action in the beams.

Structural Component: See **Component, Structural**.

Structural Performance Level: A limiting structural damage state; used in the definition of Rehabilitation Objectives.

Structural Performance Range: A range of structural damage states; used in the definition of Rehabilitation Objectives.

Structural System: An assemblage of structural components that are joined together to provide regular interaction or interdependence.

Stud: Vertical framing member in interior or exterior walls of a building.

Sub-Diaphragm: A portion of a larger diaphragm used to distribute loads between members.

Systematic Rehabilitation Method: An approach to rehabilitation in which complete analysis of the response of the building to earthquake hazards is performed.

Target Displacement: An estimate of the maximum expected displacement of the roof of a building calculated for the design earthquake.

Tie: See **Drag Strut**.

Tie-Down: A device used to resist uplift of the chords of shear walls.

Tie-Down System: For seismically isolated structures, the collection of structural connections, components, and elements that provide restraint against uplift of the structure above the isolation system.

Timber: Lumber of nominal cross-section dimensions of 5 in. or more.

Time-Effect Factor: A factor applied to adjusted resistance to account for effects of duration of load. (See **Load Duration**.)

Transverse Wall: A wall that is oriented transverse to in-plane shear walls, and resists lateral forces applied normal to its plane. Also known as an out-of-plane wall.

Unreinforced Masonry: Includes burned clay, concrete or sand-lime brick; hollow clay or concrete block; plain concrete; and hollow clay tile. These materials shall comply with the requirements of Section A106 as applicable of the IEBC.

Unreinforced Masonry (URM) Wall: A masonry wall that relies on the tensile strength of masonry units, mortar and grout in resisting design loads, and in which the area of reinforcement is less than 25 percent of the minimum ratio required by the building code for reinforced masonry.

Unreinforced Masonry Bearing Wall: A URM wall that provides the vertical support for the reaction of floor or roof-framing members.

Veneer: A masonry wythe that provides the exterior finish of a wall system and transfers out-of-plane load directly to a backing, but is not considered to add load-resisting capacity to the wall system.

Vertical Irregularity: A discontinuity of strength, stiffness, geometry, or mass in one story with respect to adjacent stories.

Waferboard: A non-veneered structural panel manufactured from 2- to 3-in. flakes or wafers bonded together with a phenolic resin and pressed into sheet panels.

Waferboard: A mat-formed wood structural panel product composed of thin rectangular wood wafers arranged in random layers and bonded with a waterproof adhesive (phenolic resin) and pressed into sheet panels.

Wall Line: Any length of wall along a principal axis of the building used to provide resistance to lateral loads. Parallel wall lines separated by less than 4 feet (1,219 mm) shall be considered one wall line for the distribution of loads.

Wall Pier: Vertical portion of a wall between two horizontally adjacent openings.

Weak Wall Line: A wall line in a story where the story strength is less than 80 percent of the story above in the direction under consideration.

Wood Structural Panel: A structural panel product composed primarily of wood and meeting the requirements of United States Voluntary Product Standard PS 1 and United States Voluntary Product Standard PS 2. Wood structural panels include all-veneer plywood, composite panels containing a combination of veneer and wood-based material, and mat-formed panels such as oriented strand board and waferboard.

Wythe: A continuous vertical section of a wall, one masonry unit in thickness.

Yield Story Drift: The lateral displacement of one level relative to the level above or below at which yield stress is first developed in a frame member.

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, American Concrete Institute, *Building Code Regulations for Reinforced Concrete*, Farmington Hills, Michigan, 2008.

AISC-360, American Institute of Construction, *Specifications for Structural Steel Buildings*, Chicago, Illinois, 2005.

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ASCE/SEI - 7, American Society of Civil Engineers (ASCE), *Minimum Design Loads for Buildings and Other Structures*, Reston, Virginia, 2005.

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IBC, International Code Council, *International Building Code*, Country Club Hills, Illinois, 2009.

NDS, American Forest and Paper Association (AF&PA), *National Design Specifications for Wood Construction*, Washington D.C., 2005.

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