

Index

A

acceleration time histories 1-35
 acceleration-sensitive nonstructural components 11-12
 acceptance criteria 2-12
 for alternative modeling parameters 2-27
 for component capacities 2-16
 for expected and lower bound strengths 2-16
 for general requirements 2-12, 3-25
 for linear procedures 3-25
 for material properties 2-16
 for nonlinear procedures 3-27
 for primary and secondary elements and components 2-12
 for strength and deformation
 of concrete 6-14
 of foundation 4-27
 of masonry 7-16, 7-18, 7-20, 7-23, 7-27, 7-30
 of steel 5-9
 of wood and light metal framing 8-13
 See also strength acceptance criteria
 actions
 deformation and force-controlled 2-14
 See also forces and deformations; deformation-controlled actions; force-controlled actions
 active control systems 9-37
 adhered veneer exterior wall elements 11-20
 adjacent buildings 2-23
 corrective measures for deficiencies in 10-10
 hazards from 2-3
 alternative modeling parameters and acceptance criteria 2-27
 backbone curve for experimental data 2-29
 data reduction and reporting 2-27
 design parameters and acceptance criteria for 2-28
 experimental setup 2-27
 Analysis Procedures 3-1
 Alternative Rational Analysis 2-12
 for nonstructural components 11-14
 Linear Dynamic Procedure (LDP) 2-8, 3-16
 Linear Procedures 2-9
 Linear Static Procedure (LSP) 3-10
 Nonlinear Dynamic Procedure (NDP) 3-24
 Nonlinear Procedures 2-11
 Nonlinear Static Procedure (NSP) 3-18
 See also general design requirements; stiffness for analysis; general analysis requirement
 anchorage to masonry walls 7-23
 anchored veneer exterior wall elements 11-20

archaic diaphragms 5-52
 architectural components 11-20
 canopies and marquees 11-29
 ceilings 11-27
 chimneys and stacks 11-29
 exterior wall elements 11-20
 interior veneers 11-26
 Nonstructural Performance Levels and damage to 1-20
 parapets and appendages 11-28
 partitions 11-25
 stairs and stair enclosures 11-30
 architectural, mechanical, and electrical components and systems 11-1
 acceleration-sensitive components 11-12
 architectural components 11-20
 deformation-sensitive components 11-12
 furnishings and interior equipment 11-39
 mechanical, electrical, and plumbing components 11-30
 nonstructural components
 assessment of 11-6
 procedures for rehabilitation 11-2
 rehabilitation concepts 11-19
 Rehabilitation Objectives 11-11
 structural-nonstructural interaction 11-12
 as-built information 2-1
 for adjacent buildings 2-3
 for building configurations 2-2
 for component properties 2-2
 for data collection requirements 2-4
 for primary and secondary elements and components 2-4
 for site characterization and geotechnical information 2-2

B

backbone curve 2-29
 base isolation. *See* seismic isolation
 base shear. *See* pseudo lateral load
 bookcases 11-39
 braced frames 5-27, 6-60
 braced horizontal steel diaphragms 5-50
 braced horizontal wood diaphragms 8-37, 8-39, 8-44
 building
 as-built information 2-2
 configuration 2-2
 historical use
 of concrete in 6-1
 of masonry in 7-1
 of steel in 5-1

- of wood and light metal framing 8-1
- irregularities 2-9
- Model Building Types for Simplified Rehabilitation 10-6
- simplified corrective measures for deficiencies in 10-17
- Building Performance Levels 1-10, 1-23
 - Collapse Prevention Level 1-25
 - Immediate Occupancy Level 1-24
 - Life Safety Level 1-24
 - Operational Level 1-24
- building pounding 2-3
- building separation 2-23
 - for seismic isolation systems 9-22

C

- canopies and marquees 11-29
- cast iron 5-54
- cast-in-place concrete diaphragms 6-61
- cast-in-place pile foundations 6-64
- ceilings 11-27
- chimneys and stacks 11-29
- chords
 - and steel diaphragms 5-52
 - and wood diaphragms 8-35
- Collapse Prevention Building Performance Level 1-25
 - as Structural Performance Level 1-14
- compressive strength of structural concrete 6-4
- computer access floors 11-40
- concrete 6-1
- condition assessment
 - for concrete 6-9
 - for masonry 7-7
 - for nonstructural components 11-2
 - for steel 5-8
 - for wood and light metal framing 8-10, 8-11
- continuity 2-20
- control node 3-18
- conveyors 11-43

D

- Damage Control Structural Performance Range 1-12
- damping
 - calculating effective
 - for energy dissipation devices 9-36
 - coefficients for modifying design response spectra 1-34
 - effective
 - for isolation systems 9-25
 - energy dissipation devices and 9-25
- DCRs (demand-capacity ratios) 2-9
- default material properties
 - for concrete 6-1

- for masonry 7-6
 - for steel 5-5
 - for wood 8-6
- deficiencies
 - for Simplified Rehabilitation Method 10-19
- deformation-controlled actions 2-13
 - using linear procedures 3-26
 - using nonlinear procedures 3-27
- deformations. *See* forces and deformations
- deformation-sensitive nonstructural components 11-12
- demand-capacity ratios (DCRs) 2-9
- design and construction review
 - for seismic isolation systems 9-22
- design review
 - for passive energy dissipation 9-34
 - foundation loads 4-2
- diagonal lumber sheathing shear walls 8-27
- diaphragms 2-21, 3-4
 - chords 2-21
 - classification 3-5
 - collectors 2-21
 - concrete 6-61
 - forces and deformations 3-15, 3-24, 3-25
 - modeling 3-5
 - precast concrete 6-63
 - steel 5-45
 - ties 2-21
 - wood 8-35
- differential compaction 4-7
- directional effects. *See* multidirectional seismic effects
- drift ratios and relative displacements 11-16
- drilled shafts 4-27
- ductwork 11-36
- dynamic vibration absorption control systems 9-37

E

- earthquake ground shaking hazard 1-27
- eccentric braced frames (EBF) 5-30
- eigenvalue (dynamic) analysis 3-11
- elastomeric isolators 9-4
- electrical components
 - electrical and communications distribution
 - components 11-37
 - electrical and communications equipment 11-36
 - Nonstructural Performance Levels and damage to 1-21
- elements and components
 - primary and secondary 3-4
- elevators 11-42
- energy dissipation devices
 - determining force-displacement characteristics of 9-36
 - displacement-dependent devices

- Linear Dynamic Procedure for 9-30
- Linear Static Procedure for 9-29
 - modeling 9-27
- general information about 9-33
- linear procedures 9-28
- modeling of 9-26, 9-27
- Nonlinear Static Procedure for 9-31, 9-32
 - other types 9-28
 - prototype tests for 9-35
 - system adequacy and 9-36
- energy dissipation systems. *See* passive energy dissipation systems
- Enhanced Rehabilitation Objectives 1-9
- expected strength
 - criteria for use of 2-17
- exterior wall elements
 - adhered veneer 11-20
 - anchored veneer 11-20
 - glass block units 11-21
 - glazing systems 11-22
 - prefabricated panels 11-22

F

- fault rupture
 - as seismic hazard 4-2
- fiberboard shear walls 8-30
- fiberboard sheathing 8-34
- fire suppression piping 11-34
- flexible diaphragm 3-5
- flooding
 - as seismic hazard 4-8
- fluid piping 11-34
- fluid viscoelastic damping devices 9-28
- fluid viscous damping devices 9-28
- footings
 - masonry 7-31
 - rigid 4-20, 4-26
 - spread 4-30
 - wood 8-44
- force deformation curve, alternative 2-29
- force-controlled actions 2-13
 - using linear procedures 3-25
 - using nonlinear procedures 3-28
- forces and deformations
 - determining with Linear Dynamic Procedure 3-17
 - determining with Linear Static Procedure 3-13
 - determining with Nonlinear Dynamic Procedure 3-25
 - determining with Nonlinear Static Procedure 3-20
- foundation acceptability criteria 4-27
- foundation loads 4-2
 - design 4-2

- foundation soil information 4-1
- foundation strength and stiffness 4-10
 - foundation acceptability criteria 4-27
 - foundation ultimate bearing pressures 4-11
 - load-deformation characteristics for foundations 4-15
- foundation ultimate bearing pressure 4-11
- foundations
 - foundation soil information 4-1
 - load-deformation characteristics for 4-15
 - masonry 7-31
 - mathematical modeling 3-4
 - retaining walls 4-28
 - shallow bearing 4-20, 4-26
 - soil foundation rehabilitation 4-29
 - stiffness of 4-10
 - ultimate bearing pressures for 4-11
 - See also* geotechnical site hazards; pile foundations
- furnishings and interior equipment 11-39
 - bookcases 11-39
 - computer access floors 11-40
 - computer and communication racks 11-41
 - conveyors 11-43
 - elevators 11-42
 - hazardous materials storage 11-41
 - storage racks 11-39

G

- general analysis requirements 3-1
 - analysis procedure selection 3-1
 - component gravity loads for load combinations 3-8
 - configuration 3-4
 - diaphragms 3-4
 - horizontal torsion 3-2
 - mathematical modeling 3-2
 - multidirectional seismic effects 3-7
 - overturning 3-9
 - P-D effects 3-5
 - soil-structure interaction 3-6
 - verification of design assumptions 3-8
- general component behavior curves
 - illustrated 2-13
- general design requirements 2-20
 - building separation 2-23
 - continuity 2-20
 - diaphragms 2-21
 - horizontal torsion 2-20
 - multidirectional seismic effects 2-20
 - nonstructural components 2-23
 - overturning 2-20
 - P-Δ effects 2-20
 - structures sharing common elements 2-23

- walls 2-22
 - See also* analysis procedures; stiffness for analysis
- Geologic Site Hazards 4-1
 - See also* Seismic Geologic Site Hazards
- glass block units 11-21
- glazing systems 11-22
- global structural stiffening 2-18
- global structural strengthening 2-19
- ground motion characterization 3-16, 3-24
- ground shaking hazards. *See* seismic hazard
- ground water conditions
 - differential compaction 4-7
 - liquefaction and 4-3
- gypsum plaster shear walls 8-31
- gypsum wallboard 8-32

H

- hazardous materials storage 11-41
- hazards. *See* Geologic Site Hazards; Seismic Geologic Site Hazards
- Hazards-Reduced Nonstructural Performance Level 1-21
- high-pressure piping 11-33
- historic status 1-6
- historical perspective
 - nonstructural components 11-6
- historical use
 - of concrete 6-1
 - of masonry 7-1
 - of steel 5-1
 - of wood 8-1
- horizontal lumber sheathing with cut-in braces
 - or diagonal blocking shear walls 8-33

I

- Immediate Occupancy Building Performance Level 1-23
 - as Nonstructural Performance Level 1-18
 - as Structural Performance Level 1-11
- Immediate Occupancy Level
 - as Building Performance Level 1-24
- infill masonry shear wall
 - model buildings
 - description 10-7
- infill panels
 - m* factors for masonry
 - infill panels 7-28
 - simplified force deflection relations masonry infill
 - panels simplified force deflection relations 7-29
- infills. *See* concrete; masonry
- in-place materials and components 6-4
 - concrete 6-60

- masonry 7-2
 - steel 5-2
 - wood and light metal framing 8-5
- in-plane discontinuity irregularity 2-10
- in-plane masonry infills 7-25
- inspection
 - for construction quality 2-25
 - for passive energy dissipation devices 9-34
 - for seismic isolation systems 9-21
- interior veneers 11-26
- inundation. *See* flooding
- isolation systems. *See* seismic isolation
- isolators
 - elastomeric 9-4
 - modeling of 9-11
 - sliding 9-8, 9-9

K

- knowledge (κ) factor
 - for concrete 6-11
 - for masonry 7-11
 - for steel 5-9
 - for wood and light metal framing 8-12

L

- landslides
 - as seismic hazard 4-7
- lateral load distribution 3-19
- Life Safety Building Performance Level 1-25
 - as Nonstructural Performance Level 1-18
 - as Structural Performance Level 1-12
- light fixtures 11-38
- light gage metal frame shear walls 8-19
- limitations
 - of Simplified Rehabilitation Method 10-4
 - on use of linear procedures 2-9
- Limited Rehabilitation Objectives 1-10
- Limited Safety Structural Performance Range 1-12
- linear analysis procedures. *See* Linear Dynamic Procedure; Linear Static Procedure
- Linear Dynamic Procedure (LDP) 3-16
 - basis of 3-16
 - determination of forces and deformations 3-17
 - modeling and analysis considerations for 3-16
- linear procedures 2-9
 - for overturning 3-9
- Linear Static Procedure (LSP) 2-11, 3-10
 - basis of 3-10
 - determination of forces and deformations 3-13
 - period determination 3-11

liquefaction
 as seismic hazard 4-3
 mitigation of 4-9
 susceptibility to 4-4, 4-14, 4-15
 load capacity for pile foundations 4-25
 load path discontinuities
 corrective measures for deficiencies in 10-9
 loads
 determining load combinations 3-8
 local risk mitigation programs A-1
 lower-bound strength 2-16
 LSP. *See* Linear Static Procedure

M

manufacturing quality control
 for energy dissipation devices 9-34
 mapped response spectrum acceleration parameters.
 See response spectrum acceleration parameters
 masonry 7-1
 masonry, reinforced
 Model Building Types
 typical deficiencies 10-25
 masonry, unreinforced
 Model Building Types
 typical deficiencies 10-25
 mass reduction 2-19
 material properties and condition assessment
 for concrete 6-4
 for masonry 7-1
 for steel 5-1
 for wood and light metal framing 8-2
 mathematical modeling. *See* modeling
 mechanical systems
 mechanical equipment 11-30
 Nonstructural Performance Levels and damage to 1-21
 mechanical, electrical, and plumbing components 11-30
 mitigation
 of Seismic Geologic Site Hazards 4-8
 See also local risk mitigation programs
 Model Building Types
 description 10-6
 typical deficiencies 10-19
 modeling
 for Linear Dynamic Procedure (LDP) 3-16
 for Nonlinear Static Procedure (NSP) 3-18
 of energy dissipation devices 9-26, 9-27
 displacement-dependent devices 9-27
 other types of devices 9-28
 velocity-dependent devices 9-27
 of isolation system and superstructure 9-14
 of soil-structure interaction 4-15

moment frames 5-10, 6-19
 multidirectional seismic effects 2-20, 3-7

N

NDP. *See* Nonlinear Dynamic Procedure
 nondestructive examination (NDE) methods
 for concrete 6-10
 nonlinear analysis procedures. *See* Nonlinear Dynamic Procedure; Nonlinear Static Procedure
 Nonlinear Dynamic Procedure (NDP) 2-12, 3-24
 basis of 3-24
 determination of forces and deformations 3-25
 modeling and analysis considerations for 3-24
 Nonlinear Static Procedure (NSP) 2-11, 3-18
 basis of 3-18
 determination of forces and deformations for 3-20
 modeling and analysis considerations for 3-18
 nonstructural components 2-23, 9-3, 11-1
 Nonstructural Performance Levels 1-17, 11-11
 NSP. *See* Nonlinear Static Procedure

O

operating temperature
 for passive energy dissipation devices 9-33
 Operational Building Performance Level 1-24
 as Nonstructural Performance Level 1-18
 Operational Level
 as Building Performance Level 1-24
 out-of-plane wall forces 2-22
 overdriven nails
 corrective measures for deficiencies in 10-18
 overturning 3-9
 for seismic isolation systems 9-21

P

parapets and appendages 11-28
 Partial Rehabilitation 1-10
 partially restrained steel moment frames 5-22
 particleboard sheathing shear walls 8-34
 partitions 11-25
 passive energy dissipation systems 9-25
 criteria selection for 9-26
 design and construction review 9-34
 detailed system requirements for 9-33
 general requirements for 9-25
 linear procedures 9-28
 modeling of energy dissipation devices 9-26, 9-27
 nonlinear procedures 9-31
 required tests of energy dissipation devices 9-34

passive programs for mitigation A-2
 selecting standards for A-3
 triggers for A-2
 P- Δ effects 3-5
 Performance Levels 1-10
 See also Building Performance Levels
 Performance Ranges
 Damage Control 1-12
 Limited Safety 1-12
 period determination 3-11, 3-20
 piers and piles 4-11
 piers, masonry 7-14
 pile caps
 lateral load path
 corrective measures for deficiencies in 10-10
 pile foundations 4-25
 concrete 6-64
 steel 5-53
 vertical load capacity for 4-25
 wood 8-44
 piping
 fire suppression 11-34
 fluid 11-34
 high-pressure 11-33
 plan irregularities
 corrective measures for deficiencies in 10-9
 plans for quality assurance 2-25
 plastic hinge rotation
 in concrete shear walls 6-51
 plate steel shear walls 5-32
 plumbing systems and components
 ductwork 11-36
 fire suppression piping 11-34
 fluid piping 11-34
 high-pressure piping 11-33
 Nonstructural Performance Levels and damage to 1-21
 storage vessels and water heaters 11-32
 pole structures 8-45
 political considerations of rehabilitation A-3
 post-tensioning anchors
 corrective measures for deficiencies in 10-18
 precast/tilt-up concrete walls
 Model Building Types
 typical deficiencies 10-23
 prefabricated panels 11-22
 Prescriptive Procedure
 for rehabilitation 11-14
 prestressing steels 6-8
 primary elements and components 3-4
 pseudo lateral load 3-13

Q

quality assurance 2-24
 construction requirements for 2-25
 plans for 2-24
 quality control
 for seismic isolation systems 9-21

R

racks
 computer and communication 11-41
 storage 11-39
 Reduced Rehabilitation Objective 1-10
 rehabilitation measures 6-29
 for concrete 6-18
 for masonry foundation elements 7-31
 for steel 5-9
 rehabilitation methods. *See* Simplified Rehabilitation Method; Systematic Rehabilitation Method
 Rehabilitation Objectives 1-8
 rehabilitation process 1-4
 rehabilitation requirements 1-1
 rehabilitation strategies 2-17
 global structural stiffening 2-18
 global structural strengthening 2-19
 local modification of components in 2-17
 mass reduction 2-19
 removal or lessening of existing irregularities 2-18
 seismic isolation 2-19
 social, economic, and political considerations A-3
 supplementary energy dissipation 2-20
 reinforced masonry bearing walls
 Model Building Types
 typical deficiencies 10-25
 Model Building Types for 10-8
 reporting and compliance procedures
 for construction quality assurance requirements 2-26
 response spectrum acceleration parameters
 adjusting for variations of viscous damping 1-34
 adjusting mapped 1-29
 for BSE-1 1-29
 for BSE-2 1-28
 general response spectrum for 1-34
 values as a function of site class and mapped short period
 spectral response acceleration 1-33

S

safety regulations A-4
 secondary elements and components 3-4
 Seismic Geologic Site Hazards 1-27, 4-2

differential compaction 4-7
 fault ruptures 4-2
 flooding 4-8
 landsliding 4-7
 liquefaction 4-3
 mitigation of 4-8
 seismic hazards 1-26
 general procedure 1-27
 seismicity zones 1-35
 site-specific procedures 1-34
 See also geologic site hazards; Seismic
 Geologic Site Hazards
 seismic isolation 9-1
 seismic isolation systems 9-3
 seismic rehabilitation process. *See* rehabilitation process
 seismicity zones 1-35
 shallow bearing foundations 4-18
 capacity parameters for 4-20, 4-26
 shared structural elements
 collecting data for 2-3
 design requirements for 2-23
 shear walls 5-32, 6-43, 8-14
 shear wave velocity 4-14, 4-18
 simplified nonlinear static analysis procedure 3-18, 3-27
 Simplified Rehabilitation Method 2-6, 10-1
 single straight sheathed diaphragms 8-35, 8-39
 site characterization 4-1
 site classes 1-31
 site soil foundation conditions 4-1
 site-specific ground shaking hazards. *See* site-seismic hazards
 slab-column concrete moment frames 6-30
 sliding isolators 9-8, 9-9
 social considerations of rehabilitation A-3
 soil
 foundation rehabilitation 4-29
 foundation soil information 4-1
 load-deformation behavior for 4-12, 4-13, 4-19, 4-23
 material improvements 4-29
 presumptive ultimate foundation pressures 4-11
 susceptibility to liquefaction 4-4, 4-14, 4-15
 soil-structure interaction (SSI) 3-6
 solid viscoelastic devices 9-27, 9-28
 spread footings and mats 4-30
 stairs and stair enclosures 11-30
 steel 5-1
 steel diaphragms 5-45
 steel plate shear walls 5-32
 steel truss diaphragms 5-49
 stiffness
 diaphragms 3-4
 effective lateral 3-20
 elastic lateral 3-20

of foundations 4-10
 See also foundation strength and stiffness;
 stiffness for analysis
 stiffness for analysis 3-4
 See also analysis and design requirements;
 analysis procedures
 storage racks 11-39
 storage vessels and water heaters 11-32
 story drift
 concrete shear wall 6-48
 strength acceptance criteria
 expected and lower bound strength 2-16
 Structural Performance Levels and Ranges 1-12
 structural-nonstructural interaction 11-12
 supplemental damping devices. *See* passive energy
 dissipation systems
 system requirements
 for passive energy dissipation systems 9-33, 9-36
 for seismic isolation systems 9-3
 See also rehabilitation requirements
 Systematic Rehabilitation Method 2-7

T

target displacement 3-21
 testing
 for concrete materials and components 6-5
 for construction quality assurance requirements 2-25
 for masonry materials and components 7-5
 for steel materials and components 5-3
 for wood and light metal framing 8-5
 prototypes for energy dissipation devices 9-35
 required for energy dissipation devices 9-34
 torsion
 accidental 3-3
 actual 3-3
 horizontal 3-2
 mathematical modeling of 3-2
 triggers for local risk mitigation programs A-2

U

URM bearing walls 10-25
 URM in-plane walls and piers
 m factors for 7-16

V

velocity-dependent damping devices 9-27
 veneer
 adhered 11-20
 anchored 11-20

vertical irregularities
 See also irregularities and discontinuities
vertical load stability
 for seismic isolation system 9-21
viscoelastic damping devices 9-28
viscous damping devices 1-34, 9-28
 visual inspections. *See* inspections

W

walls
 calculating out-of-plane wall forces 2-22
 concrete 6-43, 6-56
 general design requirements for 2-22
 masonry 7-12, 7-14, 7-17, 7-23
 retaining 4-28
 steel 5-32
 URM bearing 10-25
 wood and light frame 8-14
wood and light metal framing 8-1

Y

yield strength of component 2-16