

INDEX

- Acceleration, 515, 520
- Allowable stress design (ASD), 17, 93, 252
- Analysis:
- first-order, 363
 - first yield, 151
 - plastic analysis, 121, 152, 166, 170, 212, 364
 - second-order, 347, 363
- Axial load, redistribution, 513
- Beam-columns:
- C_m values, 349, 355
 - design criteria:
 - ASD, 356
 - LRFD, 357
 - differential equation
 - method, 349
 - lateral-torsional buckling, 356
 - moment magnification
 - method, 347
 - subjected to:
 - codification, 355
 - end moments, 352
 - transverse loads, 347
 - $P\Delta$ effect, 358, 360, 365
 - sidesway, 357
 - strength, 366, 373, 377
- Beams:
- allowable stress design:
 - bracing requirements for "compact" beams, 319
 - codification, 115
 - composite beams, 186
 - laterally stable beams, 115
 - definition of L_c , 319, 326
 - definition of L_u , 327
 - bracing, 321
 - bracing examples, 329, 332
 - C_b equation, 314
 - compact section, 115, 227, 278, 318, 326
 - continuous composite, 207
 - continuous deflection
 - formula, 175
 - continuous elastic analysis, 173
 - continuous plastic strength, 166
 - continuous splices, 172
 - curvature, 96
 - deflection, 127
 - determinate systems, 119
 - elastic analysis, 95, 105
 - flexural overstrength, 140
 - flexural strength, 99, 105, 107
 - general flexural theory, 94
 - idealization of behavior, 119, 134, 144
 - laterally supported, 115
 - lateral-torsional buckling, 302
 - analogy to pure columns, 307, 311
 - ASD design, 327
 - comparison of ASD and LRFD, 332
 - critical moment (M_{cr})
 - formulation, 307
 - elastic, 303, 307
 - inelastic, 311
 - LRFD design, 307, 315
 - limit states:
 - lateral-torsional buckling, 307
 - local flange buckling, 138
 - load and resistance factor design
 - codification, 117
 - composite beams, 193
 - definition of L_p , 315, 324
 - definition of L_{pd} , 320, 323
 - definition of L_r , 316, 325
 - laterally stable beams, 117
 - laterally unbraced beams, 316
 - shear, 118
 - moment-curvature
 - idealizations, 108, 110
 - noncompact shape, 115, 277
 - overstrength, 109, 145
 - plastic hinges, 138
 - plastic section modulus, 99
 - plastic design, codification, 116
 - residual stress, 101, 104, 118
 - section modulus, 95
 - shape factor, 110
 - irregular shapes, 112
 - I-shaped beam, 111
 - rectangular beam, 110
- Beam-to-column joints, 641
- design examples
- exterior joints, 654
 - interior joints, 646, 653
- detailing considerations, 655, 660
- wind frames, 658
- limitations on shear stresses, 649, 651
- shear:
- forces, 649
 - mechanisms, 649
 - shear stresses, 653, 654
 - strength, 651
- stiffness, 445
- Block shear, 48
- Bolts:
- A307 properties, 52
 - A325 properties, 52
 - A490 properties, 52
 - anchor bolts, 677, 679
 - block shear, 66
 - bolt spacing, 57
 - eccentricity effect of, 67
 - effective (nominal) area, 54
 - hole sizes, 56
 - nominal strength, 53
 - bearing, 56
 - root area, 54
 - shear, 55
 - shear and tension, 59
 - tension, 53
 - prestress effect, 61, 680
 - pretensioning force, 58
 - service load shear, 59
 - slip-critical connection, 58

- Bolts** (*Continued*)
 tension (external), 61
 U factor for effective net area, 51, 52
 ultimate strength, 59
 upset threads, 55
- Buckling**, 239
- Cantilever method**, 410, 414
- Code of standard practice**, 15
- Codes**, 14, 15
- Coefficient of thermal expansion**, 37
- Columns**:
 ASD design, 252
 axial shortening, 30, 39
 base restraint, 262, 677
 composite, 452
 critical stress, 249
 design aids, 256
 design for flexure, *see* Beam-column
 design strength, 254, 255
 approximate, 255, 256
 effective length, 243, 249
 alignment charts, 260, 262
 equivalent pin-end length, 241
 Euler elastic buckling, 239
 factor of safety, 254
 hinge mechanism, 581
 inelastic stiffness, 264
 LRFD design, 253, 254
 modeling, 260
 plastic hinges, 678
 post yield stability, 280
 proportional limit, 252, 253
 radius of gyration, 149
 residual stress, 147
 secondary effects, 268
 shear deformation, 617, 618
 slenderness parameters, 251, 256
 slenderness reduction factor, 264
 SSRC curves, 254
 tabular length (equivalent), 258
 torsional buckling, 302
- Composite construction**:
 ASD design procedure, 193
 design steps, 196
 example, 196
 columns, 452, 453
 connectors (shear)
 ASD design, 201
 LRFD design, 202, 204
 constructibility considerations, 195
 continuous beams, 207
 deflection, 195, 206
 effective width of slab, 189
 indeterminate systems, 212
 LRFD design procedure, 197
 design steps, 200
 mechanism methods, 211, 220
 moment strength, 192
 plastic neutral axis
 in the slab, 198
 in the steel beam, 202, 205
 section properties, 190
 serviceability considerations, 195
 service load stresses
 vibration characteristics, 220
- Conjugate beam**, 127, 421
- Connections**:
 beam-to-beam continuous, 215
 column bases, 677
 example, 678
 column-to-column, 672
 rigid frame, *see* Beam-to-column joints
- Conceptual design**, 9
- Construction documentation**, 12
- Curvature**:
 flexure, 96
 predicting maximum, 691
- D'Alembert's principle**, 515
- Damping**, 520
- Degrees of freedom**, 533, 539
- Deflection**:
 elastic, 130
 frames, *see* Story drift
 idealization, 136
 inelastic, 132
 plastic, 133
- Design**:
 allowable stress design (ASD, ASDE), v, xxii, 17, 93
 calculations, 12, 13
 concept development, 9
 development phase, 9
 intent, 12
 load, 44
 load and resistance factor design (LRFD), v, xxii, 17, 93
 load path, 9
 objectives, 8
 organization, 9
 plans, 12
 plastic design (ASDP), 17
 specifications, *see* Specifications
 working stress design, *see* Allowable stress design (ASD)
- Design earthquake**, 577
- Design response spectrum**, 528, 529, 535
- Drift**, *see* Story drift
- Ductile frames**, *see also* Frames
 behavior idealization, 687
 behavior state criteria, 580
 connector design objectives, 540
 beam-to-column, 641
 column-to-column, 672
 column shortening, 612
 conceptual member sizing, 582
 deep members, 658
 detailing the doubler plate, 655
 detailing the frame beam brace, 668
 details, 643, 673, 680
 doubler plate design, 652
 ductility demand, 697, 700
 frame-to-column base, 677
 panel zone shear, 648
 panel zone stiffness, 622
 panel zone strength, 651
 subterranean effects, 644
 welded tab plate, 660
 weld tearing, 644
 design criteria, 567, 618
 design development, 620
 design examples, 710, 718, 734
 drift control, 634
 drift limits, 575
 flange-column design, 585, 623, 626, 632
 frame sizing, 582
 irregular frames, 600
 mechanisms, 581, 712
 optimization procedures, 611
 $P\Delta$ effects, 689
 period determination, 570, 572, 574
 postyield behavior, 597, 666, 691, 696
 sequential yield analysis, 685
 spectra criteria, 577, 619

- stabilizing components, 663, 670
- time-history analysis, 693
- UBC wind criteria, 579
- Ductility, 30, 31
 - confirmation by testing, 136, 145
 - curvature, 108
 - definition, 108
 - displacement, 144, 687
 - multi-story frame, 488, 490
 - rotational, 145, 692
 - strain, 31, 143, 691, 697, 700
 - system, 490, 557, 687
 - weld, 80
- Ductility factor, 31
- Dynamic analysis, 514, 693
 - elastic response, 518, 536, 696, 699
 - inelastic response, 523, 534, 536, 697, 700
 - numerical analysis, 514, 533
 - $P\Delta$ effects, 514
 - single degree of freedom system, 514, 518
 - time-history analysis, 533, 553, 693
- Earthquake load, 16
- Earthquake magnitude, 695
- Earthquake response:
 - lumped MDOF systems, 538
 - SDOF systems, 526
- Eccentrically braced frames, 727
 - component design criterion, 742
 - component sizing, 761
 - connector design, 765, 767
 - diagonal brace design, 742
 - ductility demand, 753
 - exterior link, 750
 - flexural strains, 732
 - flexure dominant, 482, 484, 730, 740
 - fundamentals, 728
 - inactive link, 754
 - interior link, 745
 - link behavior, 730, 749
 - link detailing, 773
 - mechanisms, 741, 758
 - postyield deformation, 731
 - pure shear, 730, 731
 - shear deformation, 732
 - shear dominant, 479, 481, 730
 - story drift, 478, 744
 - strain ductility, 733
 - strength analysis, 741, 747, 751, 755, 758
 - system behavior, 762
- Effective length:
 - cantilever, 337
 - factors for columns, 242, 260
 - factors for frames, 260, 262
 - lateral support for beams, 336
 - continuous, 342
 - nonuniform moment, 314
 - plastic behavior range, 317
- Effective width, concrete slab, 189
- Efficiency factor (U) for tension members, 51
- Elastic behavior, 27, 28
 - modulus (E), 30
- Electrodes for welding, 69
- Energy-of-distortion based yield criterion, 32
- Equations of motion for
 - discrete systems:
 - damped, 521
 - inelastic, 524
 - multi-degree of freedom, 574
 - undamped, 515
- Factor of safety, 19
 - ASD, 19
 - LRFD, 45
 - slip-critical connections, 58
- Fatigue, 39
- Force distribution (lateral), 409
 - cantilever method, 411, 415
 - portal method, 412, 415
 - postyield (mechanism), 417
 - recommended, 418
- Frames:
 - braced, 473, 723, 774
 - composite construction, 451
 - confirmation of component influence, 504
 - design to drift criterion, 455
 - displacements, *see* Story drift
 - distribution of lateral forces, *see* Force distribution (lateral)
 - ductile, *see* Ductile frames
 - ductility:
 - story, 488
 - system, 490
 - flexural deformation, 421, 428, 430, 431, 450, 496
 - height-to-depth ratio, 409
 - lateral forces, 567, 569, 577, 579
 - LRFD design:
 - one-story frame, 710
 - two-story frame, 734
 - multistory, 582, 600
 - one-story
 - fixed base, 710
 - hinged base, 419, 423, 717, 718, 719
 - plastic analysis, energy method, 712
 - $P\Delta$ phenomena, 268, 359, 524, 690
 - plastic mechanisms:
 - beam sway, 417, 581
 - column hinge, 417, 581
 - reduction of lateral force resistance, 364
 - shear deformation, 411
 - stability:
 - design recommendations, 365
 - principles, 243
- High strength steels, 24
- Homogeneity, 32
- Inertia force, 515
- Iron, 7
- Isotropic, 32
- Lamellar tearing, 32
- Lateral seismic design forces:
 - determination of, 569, 574, 577
 - distribution vertically, 573
- Limit states:
 - damage control, 567, 695
 - design, 40
 - serviceability, 42
- Load:
 - combinations, 19
 - dead, 15
 - earthquake, 16
 - factor, 19
 - impact, 20
 - live, 15
 - live load reduction, 20
 - paths, 10
 - seismic, 16
 - tributary areas, 20
 - wind, 15
- Load and resistance factor design (LRFD), 17
 - load combinations, 19
- Mass, 515
- Maxwell's law of reciprocal deflections, 302
- Mechanism methods, 120

- Mill order, 12, 24
 Mode shapes, 539, 542
 Mode superposition, 539
 Modulus of elasticity:
 concrete, 190
 modular ratio, 190
 steel, 30
 Mohr's circle, 36
 Moment of inertia, 96
 based on composite system,
 190
 polar, 282
 reduced or effective, 97
 Moment redistribution, 151
 Moment-rotation
 characteristics, 110, 120,
 145, 162
 Newton's second law, 515
 Nonlinear response analysis:
 MDOF, 534
 SDOF, 523
 Normalizing mode shapes,
 539
 Orthogonality conditions, 539
 Overstrength factor:
 EBF's, 742
 general, 31, 109
 Overturning moment, 410,
 449
 Participation factor, 540
 $P\Delta$ effect, 358, 524
 Period:
 code equations, 545
 customized Rayleigh, 548
 Rayleigh's method, 546
 system specific methods,
 548
 Plastic analysis, 120, 712
 Plastic flow, 29
 Plastic hinges:
 in beams, 120, 138
 choice of locations, 123
 length, 120, 138
 locations in beams, 124
 Plastic neutral axis, *see*
 Composite construction
 Plastic section modulus, 99
 Plates:
 compared with columns,
 269
 load and resistance factor
 design, 278
 local buckling, 273
 stability introduction, 269
 stiffened elements, 276
 width/thickness limits, 276
 definitions, 279, 280
 λ , limits, 279
 λ_p , limits, 278
 Poisson's ratio, 31
 Portal method, 412, 415, 418
 Principal stresses, 32
 Proportional limit:
 beams, 102, 105
 columns, 252, 253
 rolled shapes, 28
 Quality control, 13
 Radius of gyration, 249
 Rayleigh method, 545
 approximate frequency
 analysis, 546
 improved, 548
 Reliability index, 17, 22
 Residual stresses, 28, 29
 Resistance, 12, 17
 Resistance factor, 22
 beams, 22
 compression members, 22,
 254
 fasteners, 54
 tension members, 44
 welds, 74
 Response spectra, 526
 characteristic regions, 528
 design, 535
 design tool, 538, 541
 elastic, 527
 inelastic, 529
 Saint-Venant torsion, 281
 SDOF system:
 damped response, 520
 inelastic response, 523
 $P\Delta$ effect, 524
 undamped response, 518
 Section modulus, effective,
 97. *See also* Beams
 Seismic base shear, 558
 Seismic design objectives, 568
 Seismic Provisions for
 Structural Steel Buildings
 (SPSSB), xxii
 Serviceability, 42, 46, 220
 Shear:
 block, 48
 codification, 118
 fracture, 50
 lag, 51
 modulus, 32
 rupture failure mode, 63
 strength:
 joints, *see* Ductile
 frames, connector
 design
 plastic hinges, *see* EBF's
 yield stress, 34
 Shear span, 729
 Shop drawings, 12, 14
 Sidesway, 245, 259, 357
 Slenderness parameters:
 compression, 251, 256
 plates, 275
 tension members, 40
 Span to depth ratio, 409
 Specifications, 14, 16
 American Institute of Steel
 Construction (AISC), 7,
 16
 Code of standard
 practice, 12, 15
 American National
 Standards Institute
 (ANSI), 17
 American Society for
 Testing and Materials
 (ASTM), 14
 A36 steel, 24, 25, 27, 31
 A242 high-strength low-
 alloy steel, 24
 A307 bolts, 52
 A325 bolts, 52
 A441 high-strength steel,
 24, 25, 27
 A490 bolts, 2
 A529 bolts, 24, 25
 American Welding Society
 (AWS), 13
 Design, 16
 Spectral acceleration, 526
 Spectral displacement, 528
 Square Root of Sum of
 Squares (SRSS), 542
 Stability, 238
 beams, 302
 frames, 243
 plates, 269
 Steel as a structural material,
 22
 Step-by-step integration, 516,
 533
 Stiffness:
 effective, 247, 264
 flexural, 262
 plates, 270
 of a story, *see* Story drift
 Story drift:
 beam contribution, 420,
 427, 433
 beam-to-column joint, 441
 panel zone deformation,
 444, 447
 stiffness, 441, 622
 braced frames, 473, 476
 column contribution, 420,
 427, 433
 component influence
 analysis by computer, 634
 composite construction, 451

- distributed loading, 448
- eccentrically braced frames, 478
- exterior subassembly, 427, 433
 - including panel zone, 442
- fixed base, 462
- frame flexure contribution, 421, 428, 430, 431, 450
- interior subassembly, 434
 - including panel zone, 442
 - panel zone
 - considerations, 441
 - postyield, 484
- lowermost level, 460
- multibay, 432
- multistory, 426
- nonuniform bays, 435, 459
- postyield, 484
- secondary effects, 422
 - beam shear, 422
 - centerline dimensions, 441
 - panel zone effects, 444, 447
- shear deformation, 411
- single bay, multi-story, 426, 429
- single story subassembly, 419, 423
 - including panel zone, 456
- top story, 456
- Strain:
 - aging, 30
 - hardening, 29
 - hardening modulus, 30
 - yield, 30
- Strength:
 - ideal, 110
 - overstrength, 31, 138
 - stress
 - ultimate, 30
 - residual, 28
 - yield, 30
- Strengthening existing structures, 781
 - braced frame solutions, 795
 - eccentrically braced frame alternatives, 796
 - frame solutions, 785
- Stress-strain curves, 27, 28
 - cold work effects, 29, 138
 - idealized, 109
 - strain hardening, 29, 144
 - structural shapes, 22, 23
- Tall buildings, 492
 - component influence (computer), 504
 - core drift, 494
 - frame drift, 496
 - panel zone, 501
 - stabilizing truss, 497
 - tube-braced structures, 507
- Tensile strength, 29, 48
- Tensile stress area (net), 46
- Tension members
 - ASD design, 41
 - fracture, 44, 48
 - LFRD design, 44
 - Φ factors, 44
 - stiffness design criterion, 42
 - tearing failure, 49
- Time-history analysis, 514, 533, 693
- Torsion:
 - boundary conditions, 290
 - circular sections, 281
 - constant C_w , 286
 - constant J , 282
 - differential equation, 289
 - end restraint, 290
 - flexure analogy, 286, 296
 - influence of member size, 293
 - I-shaped sections, 284
 - membrane analogy, 283
 - practical applications, 298
 - rectangular sections, 283
 - Saint-Venant, 281, 292
 - sand heap analogy, 284
 - warping, 281, 285, 294
- Torsional rigidity, 282
- U factors for effective net area, 51
- Undamped free vibrations, 517
- Uniform Building Code, 15
- Vibration characteristics of floors, 220
- Welded joints:
 - constraint, effect of, 72
 - eccentric loads
 - analysis, 78, 79
 - design, 83
 - end returns, 78
 - examples, 71
 - lap, 74
 - load-deformation relationship, 80
 - plug welds, 70
 - root opening, 70, 72
 - tension member
 - balanced connection, 78
 - examples, 77
 - fillet welds, 73
 - groove welds, 70
 - plug welds, 70
- Welding:
 - allowable stresses, 74
 - electrodes
 - coating, 68
 - designations, 69
 - matching, 69
- Welding processes:
 - shielded metal arc (SMAW), 68
 - Submerged arc (SAW), 69
- Welding symbols, table, 71
- Welds:
 - allowable resistance per inch, 76
 - fillet
 - effective throat, 75
 - maximum thickness, 73
 - minimum thickness, 73
 - single pass, 72
 - groove, 70
 - lamellar tearing, 32
 - length, minimum, 78
- Work hardening, 24
- Yielding:
 - idealized, 28, 105
 - initial, 105