

Index

A

- AASHTO Accreditation Program, 54
- AASHTO M148, 469
- AASHTO M171, 469
- AASHTO M240, 513
- AASHTO M302, 513
- AASHTO Materials Reference Laboratory, 53
- AASHTO R18, 52
- AASHTO T199, 62
- AASHTO T259, 167, 246
- AASHTO T260, 170, 311
- AASHTO T277, 246
- AASHTO T318, 64, 535
- AASHTO TP 164, 247
- AASHTO TP 64, 250
- Abrasion, 184
- Abrasion resistance, 184–192
 - application of test methods, 191
 - ASTM C 418, 187–188, 190–192
 - ASTM C 779, 187–192
 - ASTM C 944, 190
 - ASTM C 1138, 190–192
 - compressive strength and, 185–186
 - concrete types, 185–186
 - curing and, 187
 - finishing procedures and, 186–187
 - lightweight aggregate concrete, 558
 - mixture proportioning and, 185
 - quality of aggregates and, 184–185
 - roller-compacted concrete, 600
 - surface treatment and, 187
- Absolute volume method, 346
- Absorption
 - cross section, radiation shielding, 573
 - lightweight aggregates, 551–552
 - measurement, accuracy, 353–354
 - tests, 244, 358
 - water, aggregates, 351–352
- Accelerated curing, 141–149, 471
 - apparatus, 142–143
 - autogenous curing method, 143–144
 - cement chemistry effect, 146
 - experimental program, 141–142
 - high temperature and pressure method, 146–147
 - maturity method, 149–152
 - modified boiling method, 143–144
 - results, 142–144
 - test
 - precision, 145–146
 - procedure significance, 144–145
 - warm water method, 143
- Accelerating admixtures, 485
- Acceptable quality level, 22
- Acceptance plans, 22–23
- Acceptance testing, aggregates, 17–18
- ACI 116R, 59–60, 184, 467, 595, 637
- ACI 121.3R-91, 484
- ACI 121.4R-93, 484
- ACI 201.2R, 262
- ACI 207.5R, 599
- ACI-209R-92, 202
- ACI 211.1, 65, 84, 621
- ACI 211.2, 84, 339, 599, 621
- ACI 211.3R, 68–69, 599
- ACI 213, 554, 556
- ACI 214, 19–20, 28, 63, 80, 82
- ACI 216, 275
- ACI 228, 82, 137
- ACI 228.1R, 319, 324, 328
- ACI 233R, 513
- ACI 234R, 219
- ACI 301, 535
- ACI 302.1R-04, 184
- ACI 304R, 65, 592
- ACI 304.2R-96, 622
- ACI 306R, 543
- ACI 308R, 83, 467, 470, 472
- ACI 308T.G., 471
- ACI 309.1R, 59
- ACI 318, 19–20, 51, 261–262, 544, 555–556, 620
- ACI 363, 201
- ACI 503.1, 627
- ACI 503.4, 627
- ACI 506R, 616–617, 619, 622
- ACI 506.1R-98, 618
- ACI 506.2, 617, 622
- ACI 506.3-82, 617
- ACI 506.4R-94, 623
- ACI 544.2R, 587
- ACI 805–51, 616–617
- ACI E4-04, 484
- ACI SP 191, 208
- Acid attack, 263–265
- Acoustic shielding properties, 302
- Activity index
 - hydraulic cements, 437–438
 - pozzolan, 504
 - slag, 514
- Additives, content analysis in hardened concrete, 311
- Adhesive materials, epoxy resins, 626–628
- Adiabatic temperature rise, 45–46
- Admixtures
 - abrasion resistance and, 185
 - alkali-silica reactivity, 407–408
 - chemical composition, 457
 - content analysis in hardened concrete, 311
 - definitions, 495
 - drying shrinkage and, 218
 - lightweight aggregate concrete, 553, 625
 - polymer-modified concrete and mortar, 608
 - self-consolidating concrete, 639
 - shotcrete, 620
 - see also* Air-entraining admixtures; Chemical admixtures
- Aged concrete, petrographic examination, 210
- Aggregates
 - abrasion resistance and, 184–185
 - absorption measurement, accuracy, 353–354
 - acceptance testing, 17–18
 - alkali-carbonate rock reactivity, 410
 - ASTM standards, 366
 - batching and measuring materials, 539
 - bleeding and, 114–115
 - bulk density, 348–349
 - characteristics, thermal conductivity and, 227–228
 - coarse
 - degradation, 366–367
 - grading, 339

Aggregates (*continued*)

- polymer-modified concrete and mortar, 608
- with potentially expansive rock, 422
- preplaced aggregate concrete, 592
- proportions in hardened concrete, 383–384
- size and flexural strength, 134–135
- workability and, 65
- coatings, 343, 362–363
- coefficient of thermal expansion, 426–427
- compatibility with slag, 526
- compressive strength at high temperature, 279
- consistency, 12–13
- constituents, alkali reactivity, 384
- content analysis in hardened concrete, 311
- definition, 5
- deleterious substances, 360–362
- density, effect, 303
- dry rodded, 348
- elastic properties, 371
- to enhance radiation shielding
 - attributes, 573–574
- fine
 - air entrainment and, 478
 - cellular concrete, 562
 - grading, 339–340
 - manufactured, 340
 - pavement wear and, 373
 - polymer-modified concrete and mortar, 608
 - preplaced aggregate concrete, 592
 - proportions in hardened concrete, 383–384
- fineness modulus, 337–338
- fire resistance and, 277
- freeze-thaw tests, 369
- frictional properties, 372–373
- frost resistance, 290
- grading, 337–340
- hardness, 371–372
- high-density, preplaced aggregate concrete, 592–593
- high-strength, 365
- innocuous, 406–407
- Micro-Deval test, 369–370
- microscopic analysis, hardened concrete, 388
- nomenclature, 355–356, 410
- packing, 347–348
- particle size distribution, 338
- permeability, 12, 168
- physical properties, 346
- polishing, 372–373
- pores and pore distribution, 350–351
- porosity, 12
- potential alkali reactivity, 405–406
- properties, 365–366
- quarry sampling, 421–422

- reactive, 404–406
- reducing field samples to testing size, 411
- relative density, 349–350
- roller-compacted concrete, 597–598
- sampling, 411
- self-consolidating concrete, 639
- shape, 340–342
- shape and texture, 347–348
- shotcrete, 619
- size, air content measurement and, 77
- soundness, 356–360
- specifications, 374
- specific gravity, 12
- specific heat, 429
- strength, 12, 127, 370–371
- structure, 13–14
- surface moisture, 352–353
- surface texture, 342–343
- thermal expansion, 426–427
- thermal properties, 277, 425–430
- transition zone, 13
- unconfined, freeze-thaw testing, 358
- underwater abrasion test method, 368
- voids, 348–349
- void space, 13
- volume fraction and drying shrinkage, 218
- water absorption, 351–352
- wear, 372–373
- wet degradation and attrition tests, 368–370
- see also* Petrographic evaluation

Air

- entrained, factors influencing in fresh concrete, 476–480
- function in fresh and hardened concrete, 475–476

Air cells, introduction into plastic mixtures, 561

Air content, 288–304

- air-entrained concretes, 73
- effect
 - of algae in mixing water, 465
 - of hardness in mixing water, 465
 - on density, 304
- freeze-thaw damage mechanism, 289–290
- fresh fiber-reinforced concrete, 581
- fresh versus microscopic, 76–77
- hydraulic cements, 446–447
- influence on behavior and performance of concrete, 288–289
- lightweight aggregate concrete, 553
- measurement, 292
 - effect of surface preparation, 76
 - faulty testing, 78
 - future trends, 79
 - gravimetric method, 77–78
 - pressure air measurement, 75–76
 - sampling, 74

- significance and use, 73–74
- volumetric method, 76–77

pressure versus

- gravimetric, 76
- microscopic, 75

ready-mixed concrete, 537–538

sequence of material addition and, 479

supplementary cementitious materials and, 505

test, 62

test result interpretation, 300

Air-entrained concretes, air content, 73

Air-entraining admixtures, 291, 474–481

- classification, 477
- definitions, 474
- hydraulic cements, 446
- materials used as, 474–475
- ready-mixed concrete, 538
- recycled concrete, 396
- roller-compacted concrete, 598
- self-consolidating concrete, 639
- status of specifications, 481
- type and amount, 477–478

Air entrainment

- freeze-thaw durability, 73
- grading effect, 340
- workability and, 65–66

Air-free unit weight test, 61

Air voids

- determination, 480–481
- dispersion and spacing, 293–294
- entrained. purposely, 239
- freeze-thaw damage and, 289–290
- gradation, 291–292
- ice formation, 14
- large, arbitrary deletion, 298
- shape, 292
- size and distribution, 476
 - measurement, 292–293
- spacing factor, 293–294, 475

Air-void system

- achieving dispersion and small bubble spacing, 290
- calculation errors, 298
- effective, 290
- freeze-thaw durability, 476
- geometry evaluation, 294–299
 - comparison of fresh and hardened concrete, 299
- image analysis techniques, 298–299
- linear transverse method, 295–296
- microscopic analysis, 294
- modified point-conduct method, 296
- precision and bias, 296–297
- test methods, 294–296
- variability and uncertainty, 297–298

origin and geometric characteristics, 290–292

polymer-modified concrete and mortar, 609

- ready-mixed concrete, 538
- specific surface, 292–293
- test result interpretation, 299–300
- with and without air-entraining admixture, 291
- Algae, in mixing water, 465
- Alkali
 - content, fly ash and natural pozzolan, 501–502
 - extraneous sources, 407
 - release, 382
- Alkali-aggregate reactions
 - resistance to, lightweight aggregate concrete, 558
 - structures with, U. S. locations, 387, 389
- Alkali-aggregate reactivity, 108
- Alkali-carbonate rock reactivity, 410–422
 - ASTM standards, 410–411
 - chemical and mineralogical composition, 415
 - compared to alkali-silica reactivity, 413
 - concrete microbars, 421
 - concrete prism expansion test, 419–420
 - distress manifestations, 411–413
 - expansive dedolomitization reaction, 411
 - field service record, 419
 - mechanism of reaction and expansion, 417
 - petrographic evaluation, 413–415
 - potential, determination by chemical composition, 421
 - quarry sampling, 421–422
 - rock cylinder expansion test, 420–421
 - types, 411
 - using coarse aggregate with potentially expansive rock, 422
- Alkali-reactive dolomite, 384, 418–419
- Alkali silica gel, 401–402
- Alkali-silica reactivity, 401–408
 - admixtures, 407–408
 - aggregate constituents, 384
 - compared to alkali-carbonate rock reactivity, 413
 - controlling, 406–408
 - by admixtures, 487–488
 - fly ash and pozzolan, 505–506
 - gravel and sand, 387
 - hydraulic cements, 447–448
 - identifying potentially reactive aggregate, 404–406
 - limiting cement alkali level, 407
 - mechanism of reactions and distress, 402–404
 - mitigation, slag effect, 520
 - moisture availability and environmental effects, 404
 - safe reactions, 402
 - symptoms, 401–403
- Alkali sulfates, portland cement, 460
- Alkali test method, 501–502
- Aluminum, embedded, 175–177
- Ambient conditions, effects on curing, 470–471
- American Association for Laboratory Accreditation, 53–54
- ANSI A118-4, 614
- ANSI A118-6, 614
- Anti-washout admixtures, 488
- ASI 342, 244
- ASTM A 185, 620
- ASTM A 497, 620
- ASTM A 615, 620
- ASTM A 616, 620
- ASTM A 617, 620
- ASTM A 706, 620
- ASTM A 767, 620
- ASTM A 820, 578
- ASTM C 25, 459
- ASTM C 29, 348, 350
- ASTM C 31, 53, 61, 80–81, 84–85, 127–128, 136, 151–152, 544, 554
- ASTM C 33, 60–61, 185, 281, 337–343, 355, 358, 361, 366, 372, 374, 395, 397, 405, 410, 420, 447–448, 515, 562, 597, 608, 619, 621, 635–636, 639
 - grading, 337–340
 - shape, 340–342
 - surface texture, 342–343
- ASTM C 39, 46–47, 53, 61, 63, 80, 128–129, 131–132, 196, 544
- ASTM C 40, 26, 28
- ASTM C 42, 127–128, 131–132, 327, 622
- ASTM C 67, 600
- ASTM C 70, 60, 253
- ASTM C 78, 63, 80, 133–135, 196, 279
- ASTM C 85, 310
- ASTM C 88, 257, 355–357, 360, 363, 390
- ASTM C 91, 53, 635
- ASTM C 94, 19, 60–61, 63–64, 81, 441, 462, 533–545, 619, 622
 - aggregates, 539
 - batching plant, 539–540
 - cementitious materials, 538–539
 - chemical admixtures, 539
 - compressive strength testing, 543–544
 - control of water addition, 542–543
 - failure to meet strength requirements, 544
 - mixing operations, 540–542
 - mixing water, 539
 - sampling, 543
- ASTM C 109, 32, 36, 46, 437, 444, 457, 514
- ASTM C 114, 311, 451, 457–459, 500
- ASTM C 115, 292, 436–438
- ASTM C 117, 53, 343, 380, 614
- ASTM C 123, 359, 361
- ASTM C 125, 5, 59, 65, 292, 339, 383, 390, 392, 467, 474, 495, 512, 616–617
- ASTM C 127, 53, 84, 349–353, 358, 551
- ASTM C 128, 53, 84, 349–353, 358, 551
- ASTM C 131, 184–185, 359, 362, 366–368
- ASTM C 136, 53, 337, 380
- ASTM C 138, 53, 62, 77–78, 84, 289, 299, 301, 480, 534, 543, 554, 581
- ASTM C 142, 359, 361, 379, 394
- ASTM C 143, 40, 59, 61, 66–67, 74, 81, 84, 554
- ASTM C 144, 562, 635
- ASTM C 150, 53, 118, 219, 221, 234, 260, 310, 419, 435, 438–442, 444, 446–448, 450–456, 459, 562, 597, 607, 619, 635, 639
 - chemical requirements of portland cement, 453–455
- ASTM C 151, 219, 221, 437, 442, 444
- ASTM C 156, 467–469, 471
- ASTM C 157, 221–222, 420, 437, 439, 442, 587
- ASTM C 171, 620, 622
- ASTM C 172, 19, 53, 74, 82, 299, 554, 579, 581
- ASTM C 173, 53, 62, 76, 84, 480, 553–554, 581, 598
- ASTM C 177, 227, 280, 430, 564
- ASTM C 183, 18–19, 26
- ASTM C 185, 437, 447, 478
- ASTM C 186, 45, 48, 233, 437, 441–442, 457
- ASTM C 187, 44, 437, 439
- ASTM C 188, 436–438
- ASTM C 190, 444
- ASTM C 191, 43, 88, 437, 441–440, 469
- ASTM C 192, 80–81, 84–85, 127–128, 159
- ASTM C 204, 292, 436–438
- ASTM C 206, 503
- ASTM C 207, 635
- ASTM C 214, 450
- ASTM C 215, 46, 155, 157, 200, 315–316, 318–319
- ASTM C 219, 5, 474
- ASTM C 227, 179, 212, 395, 404–405, 437, 439, 444, 447, 457
 - limitations, 405
- ASTM C 231, 62, 75, 77, 84, 299, 476, 480, 537, 553, 581, 598
- ASTM C 232, 115, 119–121
- ASTM C 233, 481
- ASTM C 234, 107
- ASTM C 235, 361
- ASTM C 236, 280
- ASTM C 243, 119–120
- ASTM C 260, 19, 157–158, 474, 480–481, 620, 639
- ASTM C 265, 446, 448
- ASTM C 266, 43, 88, 437, 440–442
- ASTM C 267, 265

- ASTM C 270, 632, 635
 ASTM C 289, 179, 404–405
 limitations, 405
 ASTM C 290, 154–157
 ASTM C 291, 154–155, 157
 ASTM C 292, 155
 ASTM C 293, 63, 80, 133–135, 196
 ASTM C 294, 39, 410, 575
 ASTM C 295, 39, 208, 215, 359,
 361–363, 377–378, 380–381,
 397–398, 404–405, 410–411, 425
 ASTM C 309, 19, 469–471, 601, 620, 622
 ASTM C 310, 155
 ASTM C 311, 18, 437, 497, 499, 501,
 505–509
 ASTM C 330, 158, 374, 548–550,
 556–557, 559, 565, 619
 ASTM C 331, 549–550, 562
 ASTM C 332, 549–550, 562
 ASTM C 341, 221–222
 ASTM C 348, 444
 ASTM C 349, 444
 ASTM C 350, 497–499
 ASTM C 359, 440
 ASTM C 360, 67
 ASTM C 387, 631–632, 634–635
 packaged, dry, cementitious mixtures,
 632
 ASTM C 401, 53
 ASTM C 402, 498
 ASTM C 403, 86–88, 90–91, 93–97, 142,
 441
 precision, 88–89
 ASTM C 418, 187–188, 190–192, 366
 ASTM C 430, 437–438, 503
 ASTM C 441, 407–408, 439, 447, 505,
 508, 514
 ASTM C 451, 437, 440
 ASTM C 452, 260, 262, 437, 447–448
 ASTM C 457, 75–76, 79, 239–240, 288,
 292–300, 310–311, 380, 383–384,
 390, 398, 476, 480–481, 538
 methods, 294–296
 microscopic analysis, 294
 precision and bias, 296–297
 ASTM C 464, 316
 ASTM C 465, 454
 ASTM C 469, 196–197, 200, 556
 ASTM C 470, 81
 ASTM C 490, 155, 232
 ASTM C 494, 19, 88–89, 157–158, 160,
 168, 441, 485–489, 562, 598, 623,
 639
 ASTM C 495, 565
 ASTM C 496, 63, 80, 133, 135, 556, 559,
 565
 ASTM C 511, 83–84
 ASTM C 512, 81, 202, 556
 ASTM C 518, 228
 ASTM C 535, 359, 362
 ASTM C 563, 437, 446, 454
 ASTM C 566, 60, 253
 ASTM C 567, 301, 303, 548, 554, 559
 ASTM C 579, 579
 ASTM C 586, 411, 413, 417–418,
 420–422
 ASTM C 595, 53, 234, 435, 437–438,
 441, 444–448, 456, 513, 515, 517,
 562, 619, 635, 639
 blended hydraulic cements, 456
 ASTM C 596, 221–222, 439
 ASTM C 597, 199–200, 318, 623
 ASTM C 617, 129–130
 ASTM C 618, 114, 232, 260, 407, 442,
 456–457, 479, 498–500, 504–507,
 509, 562, 591, 597, 619
 ASTM C 637, 570, 575, 592, 619
 ASTM C 638, 570, 575, 592
 ASTM C 642, 239, 244, 250, 303
 ASTM C 666, 154–161, 212, 359, 361,
 480, 557, 600, 610
 ASTM C 670, 26, 28, 145, 158, 160, 357
 ASTM C 671, 155–156, 160–161, 359
 ASTM C 672, 26, 155–156, 161–162,
 267, 524
 ASTM C 682, 155–156, 160–162, 359
 ASTM C 684, 141, 143, 145–147, 152
 ASTM C 685, 533–534, 536, 543–544,
 619, 622
 ASTM C 702, 411
 ASTM C 778, 444
 ASTM C 779, 187–192, 366
 ASTM C 796, 562, 564
 ASTM C 801, 137
 ASTM C 802, 26, 28
 ASTM C 803, 136, 325, 328, 622
 ASTM C 805, 136–137, 324, 622
 ASTM C 806, 223
 ASTM C 823, 20, 204–209, 379, 411,
 419, 581, 622–623
 ASTM C 827, 221–222, 439, 633
 ASTM C 845, 53, 219, 607
 ASTM C 851, 361
 ASTM C 856, 170, 207–208, 210,
 310–311, 379, 398, 411–412
 ASTM C 869, 562
 ASTM C 873, 127–128, 136
 ASTM C 876, 170
 ASTM C 878, 221, 223
 ASTM C 881, 620, 626–627
 ASTM C 882, 627, 633
 ASTM C 884, 627–628
 ASTM C 887, 635
 ASTM C 900, 136, 328–329
 ASTM C 903, 618
 ASTM C 917, 19, 26, 32, 36, 445
 ASTM C 918, 27, 136, 141, 149–150,
 152, 330
 ASTM C 928, 632–635
 packaged, dry, cementitious mixtures,
 632–633
 ASTM C 936, 600
 ASTM C 937, 570, 576, 592
 ASTM C 938, 570, 576, 592
 ASTM C 939, 69, 570, 576, 593
 ASTM C 940, 119, 221, 223, 570, 576, 593
 ASTM C 941, 119, 570, 576, 593
 ASTM C 942, 570, 576, 593
 ASTM C 943, 570, 576, 594
 ASTM C 944, 190, 366
 ASTM C 953, 570, 576, 594
 ASTM C 973, 618
 ASTM C 989, 18, 408, 437, 456,
 513–515, 517, 521, 528, 597, 619
 use of appendices, 514
 ASTM C 1012, 260–261, 437, 439,
 447–448, 457, 506, 521
 ASTM C 1017, 19, 157–158
 ASTM C 1018, 196, 198, 579, 584–586,
 589, 617, 621
 ASTM C 1038, 437, 446, 448, 454
 ASTM C 1040, 303
 ASTM C 1059, 625–626
 ASTM C 1064, 53, 63, 74, 84
 ASTM C 1067, 26
 ASTM C 1069, 508
 ASTM C 1073, 514–515
 ASTM C 1074, 79, 149–150, 152, 331,
 472
 ASTM C 1077, 52–54, 378, 543
 ASTM C 1078, 63
 ASTM C 1079, 64
 ASTM C 1084, 212, 263, 309–311
 ASTM C 1090, 221, 223
 ASTM C 1102, 617
 ASTM C 1105, 411, 419–422
 ASTM C 1107, 591, 633–635
 packaged, dry, cementitious mixtures,
 633
 ASTM C 1116, 579, 582, 617–620,
 622–623
 ASTM C 1117, 617
 ASTM C 1137, 366, 369
 ASTM C 1138, 186, 190–192, 366, 368,
 600
 ASTM C 1140, 617, 620, 622–623
 ASTM C 1141, 617, 620, 622–623
 ASTM C 1151, 244, 469
 ASTM C 1152, 170, 311
 ASTM C 1157, 53, 221, 435, 437–438,
 440–442, 444–448, 456–459, 562,
 619, 635, 639
 ASTM C 1170, 63, 68–69, 599, 602–603
 ASTM C 1176, 81, 84, 603
 ASTM C 1202, 47, 167–168, 246–247,
 250, 520, 610
 ASTM C 1218, 171
 ASTM C 1222, 53–54
 ASTM C 1231, 129–130, 544
 ASTM C 1240, 19, 408, 456–459,
 507–508, 619
 ASTM C 1252, 341–343
 ASTM C 1260, 378, 404–406
 ASTM C 1293, 404, 406, 510–521
 ASTM C 1294, 419
 ASTM C 1315, 19, 470, 629
 ASTM C 1324, 212, 311
 ASTM C 1356, 209, 459
 ASTM C 1362, 63, 67

- ASTM C 1365, 459
 ASTM C 1383, 200, 320
 ASTM C 1385, 617, 621
 ASTM C 1398, 617, 620, 623
 ASTM C 1399, 579, 584, 586–587
 ASTM C 1402, 625
 ASTM C 1404, 625
 ASTM C 1435, 81, 84, 603
 ASTM C 1436, 617, 619, 621, 623
 ASTM C 1437, 437, 439
 ASTM C 1438, 608, 615, 620
 ASTM C 1439, 608
 ASTM C 1451, 19, 27, 30, 36
 ASTM C 1452, 568
 ASTM C 1453, 167
 ASTM C 1480, 617, 619, 621, 623
 ASTM C 1543, 246, 250
 ASTM C 1550, 584, 587, 589, 617–618, 623
 ASTM C 1556, 47, 168, 246, 250
 ASTM C 1558, 244, 250
 ASTM C 1567, 514, 520
 ASTM C 1581, 204, 221–222
 ASTM C 1583, 628
 ASTM C 1585, 168, 244, 250
 ASTM C 1602, 462–463
 ASTM C 1603, 463, 537
 ASTM C 1604, 617, 622
 ASTM D 75, 17, 380, 411
 ASTM D 448, 337
 ASTM D 672, 610
 ASTM D 1557, 599, 603
 ASTM D 2419, 361
 ASTM D 2766, 229
 ASTM D 2936, 133–134
 ASTM D 2940, 598
 ASTM D 3042, 366, 373
 ASTM D 3319, 366, 373–374
 ASTM D 3398, 341
 ASTM D 3665, 20, 25
 ASTM D 3744, 368
 ASTM D 4326, 499
 ASTM D 4397, 469
 ASTM D 4460, 27
 ASTM D 4580, 111
 ASTM D 4748, 322
 ASTM D 4788, 321
 ASTM D 4791, 340–343
 ASTM D 4944, 60
 ASTM D 4971, 39
 ASTM D 5882, 320
 ASTM D 6087, 322
 ASTM D 6607, 27
 ASTM D 6928, 366, 369
 ASTM E 6, 195–196, 201
 ASTM E 11, 337
 ASTM E 96, 243, 250, 469
 ASTM E 105, 20
 ASTM E 119, 274–275, 283, 558, 566
 ASTM E 122, 20, 25
 ASTM E 141, 20
 ASTM E 177, 211
 ASTM E 288, 428
 ASTM E 289, 428
 ASTM E 303, 373
 ASTM E 329, 52
 ASTM E 350, 459
 ASTM E 660, 366, 373
 ASTM E 707, 366
 ASTM E 994, 52
 ASTM E 1085, 514
 ASTM E 1187, 52
 ASTM E 1301, 52
 ASTM E 1323, 52
 ASTM E 1550, 52
 ASTM E 1738, 52
 ASTM E 2159, 52
 ASTM E 2226, 275
 ASTM F 1869, 243, 250
 ASTM F 2170, 244, 250
 ASTM G 40, 184
 Atmospheric diffusion, shrinkage and, 219
 Atom, model, 570
 Attrition test, aggregates, 368–370
 Autogenous shrinkage, 7
 Autogenous volume changes, 216
- B**
- Backscattered electron SEM, 39–40
 Ball-bearing abrasion test machine, 189–190
 Ball penetration test, 67
 Basic water content, 12
 Batching
 roller-compacted concrete, 601
 self-consolidating concrete, 641
 sequence of material addition, air content and, 479
 shotcrete, 621–622
 Batching plant, ASTM C 94, 539–540
 Bearing strips, splitting tensile strength and, 135
 Beneficiation, petrographic evaluation and, 379
 Bias, 296–297
 chemical analysis of hydraulic cement, 458
 statements, acceptance testing, 26–27
 sulfate soundness test, 356–357
 Binders, shotcrete, 619
 Bituminous coatings, 628–630
 Bituminous materials, contamination of recycled concrete, 396
 Blaine fineness, 39
 Blaine test, 438–439
 Blast-furnace slag, see Slag
 Bleeding, 239
 capacity, 101–103
 controlling, 118–119
 duration of, 101–102
 effects on hardened concrete, 106
 blisters, 111
 durability, 107–108
 mortar flaking, 109
 paste-aggregate bond, 106–107
 paste-steel bond, 107
 scaling, 108–109
 strength and density, 106
 surface appearance, 111–112
 surface determination, 109–111
 effects on plastic concrete, 102–106
 placing and finishing, 106
 plastic shrinkage, 104–106
 postbleeding expansion, 103–104
 thixotropic mixtures, 106
 volume change, 102–103
 water-cement ratio, 106
 fresh concrete, slag effect, 518
 fundamentals, 99–101
 increasing, 118
 ingredient effects, 112–116
 aggregate, 114–115
 cement, 112–113
 chemical admixtures, 115
 supplementary cementing materials, 113–114
 water content and water-cement ratio, 112
 mathematical models, 119, 121
 placement conditions, 116–118
 planes of weakness due to, 128
 rate, 101–102
 reducing, 116, 118
 significance, 99
 special applications, 119
 test methods, 119–121
 zones, 101–102
 Bleed-reducing admixtures, 116
 Bleed water, 118–119, 558
 Blended cement, slag, 515
 Blistering, 111, 289
 Bogue calculations, 451–452
 Bond, polymer-modified concrete and mortar, 609–611
 Bond breakers, new concrete surfaces, 471
 Bonded capping, 129–130
 Bonding materials, organic, 625–626
 Brickwork, contamination of recycled concrete, 397
 Brines, 265–266
 Brucite, 418
 BS 812, 369, 373
 BS 1881, 244
 Bulk density, aggregates, 348–349, 549–550
 Bulk modulus, high temperature and, 280
- C**
- Calcium chloride in admixtures, 485
 bleeding and, 116
 effect on galvanic current, 176–177
 Calcium hydroxide
 crystals, 13
 hydration product, 254

- Calcium hydroxide (*continued*)
 - involved in leaching or mineral deposition, 255
 - sulfate resistance and, 260
- Calcium nitrite, permeability and, 169
- Calcium oxide
 - analysis, 310
 - expansion due to hydration, 219, 221
- Calcium silicate hydrate, 6, 8–9
- Calcium sulfate, portland cement, 459–460
- Calcium sulfate reaction, 257–258
- Calcium sulfoaluminates, sulfate attack and, 256
- California Division of Highways, 160
- Capillary absorption tests, 244
- Capillary tension, pore water, 9
- Capping procedures, 129–130
- Carbonate, portland cement, 459
- Carbonate rocks, alkali-carbonate rock reactivity, 411
- Carbonation
 - Chemical resistance, 266
 - depth of, 243
 - portland-cement paste, 174
- Carbonation shrinkage, 216–217
- Carlson-Forbrich van conduction calorimeter, 233
- Casting direction, compressive strength, 132
- Casting techniques, cellular concrete, 564
- Cast-in-place concrete, radiation shielding, 575
- Cathodic protection, reinforcing steel, 171
- Cellular concrete, 561–568
 - air cell introduction, 561
 - applications, 567
 - batching, mixing, and application techniques, 563–564
 - classification, 562
 - compressive strength, 565
 - density, 564
 - drying shrinkage, 566
 - energy absorption, 566
 - engineered fills, 567
 - fire resistance, 566
 - floor fills, 567
 - freeze-thaw resistance, 566
 - materials, 562–563
 - modulus of elasticity, 566
 - nailability and sawability, 567
 - precast elements, 567–568
 - proportioning, 563
 - quality control, 568
 - roof deck fills, 567
 - shear strength, 566
 - tensile strength, 565
 - thermal conductivity, 564–565
 - walkability, 566–567
 - water absorption, 566
 - workability, 564
- Cement
 - air entrainment and, 478
 - analysis of type, 310–311
 - bleeding and, 112–113
 - cellular concrete, 562
 - classification, 436
 - fresh, rheology, 40–41
 - hardened, modeling degradation and service life, 47
 - particle shape, 39–40
 - polymer-modified concrete and mortar, 607
- Cement-aggregates combinations, potential alkali reactivity, 405
- Cement and Concrete Reference Laboratory, 53
- Cement chemistry, accelerated curing methods and, 146
- Cement content
 - analysis, 309, 311
 - fresh concrete, 64
 - petrographic evaluation, 310
 - uniformity, tests, 63–64
- Cement gels, 9
- Cementing materials, preplaced aggregate concrete, 591
- Cementitious materials
 - acceptance testing, 18–19
 - paste strength and, 126
 - roller-compacted concrete, 597
 - see also* Packaged, dry, cementitious mixtures; Supplementary cementitious materials
- Cement maintenance paint, latex-modified, 614
- Cement mix, workability and, 65
- Cement mortar, volume change, 222–223
- Cement particles, dispersion, 6
- Cement paste
 - composition and fire resistance, 276–277
 - compressive strength, 11
 - creep, 10–11, 201
 - density, 126
 - diffusivity, 11–12
 - elasticity, 10–11
 - film thickness and aggregates, 13
 - fresh, structure, 6
 - hardened, properties, 46–47
 - hardening, properties, 41–46
 - permeability, 11–12
 - rheology, 10
 - strength, 126
 - thermal expansion, 12, 230
 - thermal properties, 226
 - water content, drying shrinkage, 218, 220–221
 - X-ray diffraction, 212
- Cement paste matrix, 5
- CEMHYD3D, 42–46, 472
- CEN/TC 154, 367
- Center-point loading, flexural strength, 135
- Central mixing, ready-mixed concrete, 540–541
- Centrifuge test, 63
- Ceramic tile thinsets, latex-modified, 614
- Certification, testing personnel, 81
- Chemical admixtures, 484–489
 - accelerating, 485
 - acceptance testing, 19
 - air-entraining, 478
 - batching and measuring materials, 539
 - bleeding and, 115–116
 - cellular concrete, 563
 - cold weather, 488–489
 - compatibility with slag, 526
 - corrosion-inhibiting, 486–487
 - high-range water reducing, 486
 - hydration and, 233
 - hydration controlling, 489
 - mid-range water reducing, 486
 - paste strength and, 126
 - recycled concrete, 396
 - shrinkage-reducing, 488
 - suppression of alkali-silica reactions, 487–488
 - viscosity-modifying and anti-washout, 488
 - water-reducing and set-retarding, 484–485
 - workability and, 66
- Chemical attack, 253–254
- Chemical contamination, recycled concrete, 396
- Chemical reactions
 - mechanisms in deterioration, 253
 - supply of aggressive agents, 254
- Chemical resistance, 253–267
 - acid attack, 263–265
 - attack by other chemicals, 266–267
 - carbonation, 266
 - efflorescence, 254–256
 - improving, 254–256
 - leaching, 254–256
 - scaling, 254–256
 - seawater and brines, 265–266
 - sulfate resistance, 256–263
 - see also* Sulfate resistance
- Chemical shrinkage, 7, 9, 44–45, 216
- Chert, 360–361
- Chi-square test, 20
- Chloride
 - analysis in reinforcing steels, 170–171
 - effect on sulfate resistance, 259
 - ion effect, 167–168
- Chloride-induced corrosion, 164–167
- Chloride penetration, 164
 - prestressed concrete, 169
 - seawater and, 265
 - test methods, 245–247

- Clay
 - in alkali-carbonate rocks, 447–448
 - expanded, petrographic evaluation, 394
- Clay lumps, 360–361, 379
- Clinker particles, 8
- Clinker phases, 39, 452
- Coal, 360–361
- Coatings
 - abrasion resistance and, 187
 - aggregates, 343, 362–363
 - artificially generated, 362
 - bituminous, 628–630
 - definition, 355–356
 - effect on concrete, 362–363
 - embedded lead, 177–178
 - latex, 629–630
 - naturally occurring, 362
 - on gravel and sand, 386
 - petrographic evaluation of
 - aggregates, 383
 - polymer-modified concrete and mortar, 613–614
 - synthetic-resin, 629
- Coefficient of thermal expansion, 278, 426–427
- Coefficient of variation, 23
- Cohesion, air content and, 289
- Cold weather admixtures, 488–489
- Color, slag effect, 524–526
- Compactability, roller-compacted concrete, 602–603
- Compaction, roller-compacted concrete, 601–602
- Composition, petrographic examination, 210–211
- Compression
 - creep measurement, 202
 - modulus of elasticity, 196–198
- Compressive members, deflection, 203
- Compressive strength, 80
 - abrasion resistance and, 185–186
 - cellular concrete, 565
 - cement paste, 11
 - elastic properties and, 200–201
 - factors affecting, 129–132
 - high temperature and, 278–279
 - lightweight aggregate concrete, 555–556
 - preplaced aggregate concrete, 593
 - ready-mixed concrete, 543–544
 - recycled concrete, 395–396
 - roller-compacted concrete, 600
 - test procedures, 128–129
 - test result significance, 132–133
 - virtual testing, 46–47
- Compressometer, 197
- Concrete
 - bleeding capacities, 101, 103
 - definition, 5
 - hardening, properties, 41–46
 - microbars, 421
 - normal consistency, measurement, 66–68
 - physical properties, curing effects, 470
 - recycled, embedded in new concrete, 181–182
 - types, abrasion resistance and, 185–186
 - volume change, 222–223
 - see also* Fresh concrete; Hardened concrete
- Concrete-making materials
 - definition, 5
 - perceived relative importance of materials, 32–35
 - properties and performance, 30–35
 - see also* Uniformity, concrete-making materials
- Concrete prism expansion test, 419–420
- Concrete rheometer, self-consolidating concrete, 643
- Consistency
 - aggregates, 12–13
 - hydraulic cements, 439–440
 - roller-compacted concrete, 602–603
 - workability and, 65
- Consolidation
 - bleeding and, 117–118
 - fresh concrete, slag effect, 517–518
 - laboratory specimens, 84
- Construction, roller-compacted concrete, 601–602
- Construction Materials Engineering Council, 54
- Construction Materials Reference Laboratories, 53
- Contact zone, lightweight aggregate concrete, 557–558
- Contamination
 - detection, petrographic evaluation, 379
 - recycled concrete, 396
- Continuous penetration measurement, 91–92
- Control chart, 27–28
- Copper and copper alloys, embedded, 178
- Core and pullout test, 329
- Cored specimens, 128, 130, 170
- Core testing, versus probe penetration test, 327
- Corps of Engineers method, 599
- Correlation coefficient, 23
- Corrosion
 - chloride-induced, 164–167
 - embedded asbestos, 181
 - embedded aluminum, 175
 - embedded concrete, 181–182
 - embedded copper and copper alloys, 178
 - embedded fibers, 180–181
 - embedded glass, 179
 - embedded lead, 177–178
 - embedded organic materials, 181
 - embedded plastics, 180
 - embedded steel, 181
 - embedded zinc, 178–179
 - mechanisms, 164–166
 - reinforced steel, 164–171
 - assessing severity in existing structures, 170
 - cathodic protection, 171
 - chloride ion effect, 167–168
 - chloride samples, 170–171
 - concrete cores, 170
 - damage, 166–167
 - new steels, 171
 - precautionary steps against, 168–169
 - prestressed concrete, 169–170
 - repairs to deteriorated structures, 171
 - wood, 179–180
- Corrosion-inhibiting admixtures, 486–487
- Corrosion resistance, hardened cement, slag effect, 520
- Crack damage, alkali reactivity, 411
- Cracking, 216
 - fire-damage, 283–284
 - resistance, fiber-reinforced concrete, 587–589
- Crank's solution, 246
- CRD-C 36, 230
- CRD-C 37, 230
- CRD-C 38, 233
- CRD-C 39, 232
- CRD-C 44, 227
- CRD-C 45, 228
- CRD-C 55–92, 61
- CRD-C 124, 229
- CRD-C 148, 368
- CRD-C 300, 470
- CRD-C 302, 470
- CRD-C 401, 465
- CRD-C 621–89a, 633
- Creep, 14, 201–203, 215
 - cement paste, 10–11, 201
 - effect of specimen size, 202
 - high temperatures and, 280
 - importance, 194
 - lightweight aggregate concrete, 556–557
 - measurement in compression, 202
 - property specification and estimation, 202–203
 - significance and use, 203
 - tensile, measurement, 202
- Creep coefficient, 202–203
- Crushing, particle shape, 341–342
- Crusted stone, petrographic evaluation, 390–392
- CSA A23.1, 481
- CSA A23.2–14A, 419–420, 422
- CSA A23.2–23A, 369
- CSA A3001, 513

Curing
 abrasion resistance and, 187
 accelerated, 471
 ambient conditions effects, 470–471
 effects on concrete properties, 470
 fresh concrete, slag effect, 519
 internal, 471–472, 553–554
 liquid membrane-forming curing
 compounds, 469–470
 materials for water retention, 468
 needs for future work, 472–473
 new concrete surfaces, 469–473
 effectiveness, 467–468
 paste strength and, 126
 roller-compacted concrete, 602
 self-consolidating concrete, 642
 sheet materials, 469
 specimens, 83
 test methods, 468–469
 Curing compounds, 19, 629
 Curing meter, 472
 Curing water, 465–466, 619–620
 Cylinder strength, 130

D

Damping properties, 316
 Dams, roller-compacted concrete,
 595–596
 Darcian flow, 241–242
 Darcy's law, 245
 D-cracking, 156
 Decorative coatings, polymer-modified
 concrete and mortar, 613
 Dedolomitization, 417–418
 expansive, 411
 Deflection, compressive and flexural
 members, 203
 Degradation, coarse aggregates,
 366–367
 modeling, 47
 Degree of consolidation, density,
 301–302
 Degree of hydration, 41–43
 Dehydration, during fires, 276–277
 Deicing salts, 164, 245, 524
 Delamination
 air content and, 289
 bleeding, 109–111
 detection, ground-penetrating radar,
 321–322
 Delayed ettringite formation, 257, 260,
 262–263
 Deleterious substances
 aggregates, 360–362
 definition, 355
 slag, 393
 see also Alkali-silica reactivity
 Density, 300–304
 air content effect, 289, 304
 cellular concrete, 564
 cement paste, 126
 composition effect, 303–304

degree of consolidation, 301–302
 determination, 303
 fresh fiber-reinforced concrete, 581
 hardened concrete, bleeding and,
 106–112
 hydraulic cements, 436, 446–448
 in-place, roller-compacted concrete,
 603
 lightweight aggregate concrete, 554
 measurement
 as cross-check to air content
 measurement, 77–78
 significance and use, 73
 paste content effect, 304
 permeability, 301
 preplaced aggregate concrete, 594
 radiation shielding, 574
 shielding properties, 302
 significance, 301–302
 test, 62–63
 typical values, 302–303
 uniformity of materials, 301
 voids content, 301
 Deteriorated structures, repairs, 171
 Diameter-aggregate size ratio, compres-
 sive strength and, 131
 Diatomite, petrographic evaluation, 395
 Difference two sigma limit, 23, 26
 Diffusion coefficients, 11–12
 Diffusivity
 cement paste, 11–12
 high temperatures, 280–281
 virtual testing, 47
 Digital recorders, 540
 Dilation methods, freezing and
 thawing, 160–161
 Dilatometry tests, fire resistance, 276
 DIN 1048, 244–245
 Direct tension test, 134
 Discontinuity, 247–249
 Dissipative particle dynamics approach,
 41
 Distress, due to alkali-carbonate rock
 reactivity, 411–412
 Dolomitic carbonate rocks, petro-
 graphic evaluation, 421
 Dressing-wheel abrasion test machine,
 189
 Drilled cores, strength testing, 127–128
 Drilled-in pullout test, 329
 Drying
 effects, 9–10
 new concrete surfaces, 472
 time, 174–175
 Drying shrinkage, 215, 217–219
 cellular concrete, 566
 hydraulic cements, 442
 slag effect, 523–524
 supplementary cementitious
 materials, 505
 Dry shake hardeners, new concrete
 surfaces, 471
 Dunagantest, 61

Durability, 14, 80
 bleeding and, 107–108
 fiber-reinforced concrete, 589
 hydraulic cements, 446–448
 improvement, 254
 lightweight aggregate concrete, 557
 roller-compacted concrete, 600–601
 Durability factor, freezing and thawing,
 157
 Dynamic modulus of elasticity, 314–316
 Dynamic modulus of rigidity, 315–316

E

Echo method, 319–320
 Efflorescence, 254–256, 524
 Elastic constants, 194–196
 Elasticity, cement paste, 10–11
 Elastic modulus, 11, 194–195
 drying shrinkage and, 218
 from ultrasonic measurements,
 199–200
 virtual testing, 46
 Elastic properties, 196–201
 aggregates, 371
 elastic modulus, from ultrasonic
 measurements, 199–200
 importance, 194
 modulus of elasticity
 in compression, 196–198
 in tension and flexure, 198–199
 Poisson's ratio, 200
 property specification and estima-
 tion, 200–201
 significance and use, 203
 Elastic strain, 215
 Electrolytic cell, 165–166
 Electrical methods, time of setting,
 95–96
 Embedded materials, 174–182
 aluminum, 175–177
 asbestos, 181
 concrete, 181–182
 copper and copper alloys, 178
 fibers, 180–181
 general condition, 174–175
 glass, 179
 glass fibers, 181
 lead, 177–178
 organic materials, 181
 other metals, 179
 plastics, 180
 steel, 181
 corrosion-inhibiting admixtures,
 486–487
 wood, 179–180
 zinc, 178–179
 see also Corrosion, reinforced steel
 EN 1097-1:1996, 367
 EN 1097-2:1998, 367
 EN 1097-8:1999, 367
 EN 1097-9:1998, 367
 EN 197, 222

- End conditions, specimen, compressive strength and, 129–130
- Energy absorption, cellular concrete, 566
- Engineered fills, cellular concrete, 567
- Entrained air, factors influencing in fresh concrete, 476–480
- Environment, of concrete, effect on petrographic examination, 211–212
- Environmental benefits
 - self-consolidating concrete, 638–639
 - slag, 527–528
- Epoxy, permeability and, 169
- Epoxy-coated reinforcing steel, fire resistance, 278
- Epoxy resins, as adhesive, patching, and overlaying materials, 626–628
- Erosion resistance, roller-compacted concrete, 600
- Ettringite, 257, 260, 262–263
- Evaporation rate, bleeding and, 105
- Expansive cements, volume change, 219–221
- Expansive dedolomitization reaction, 411
- Exterior insulation finish systems, polymer-modified concrete and mortar, 613
- F**
- Failure, contact zone and, 558
- False set, 8, 440
- Fatigue strength, 137–138
- Fiber content, fresh fiber-reinforced concrete, 581–582
- Fiber-reinforced concrete, 578–589
 - fresh, 579–582
 - hardened, 582–589
 - cracking resistance, 587–589
 - durability, 589
 - dynamic loading, 587
 - fiber content and orientation, 582
 - static loading, 582–587
- Fiber reinforcement
 - cellular concrete, 563
 - shotcrete, 618
- Fibers, air entrainment and, 478
- Fick's first law, 243
- Field concrete
 - penetration resistance versus time, 91
 - petrographic examination, 210–212
- Field curing, specimens, 83
- Fine materials
 - as deleterious substances, 360–361
 - workability and, 66
- Fineness
 - hydraulic cements, 438–439
 - slag, 514
 - supplementary cementitious materials, 503
- Fineness modulus, 337–338
- Finishability, fresh concrete, slag effect, 517–518
- Finisher's foot, 90
- Finishing
 - abrasion resistance and, 186–187
 - air content and, 289
 - bleeding and, 106
 - self-consolidating concrete, 642
- Fire damage, investigation and repair, 284–285
- Fire endurance standards, 275
- Fire resistance, 274–286
 - aggregate component and, 277
 - cellular concrete, 566
 - cement paste component and, 276–277
 - embedded steel, 277–278
 - factors influencing behavior, 275–276
 - lightweight aggregate concrete, 558–559
 - spalling and cracking, 283–284
 - testing, 274–275
 - see also* High temperature, 279
- Flash set, 7, 440
- Flexural deflection, 203
- Flexural strength, 80, 134–136
- Flexural strength testing, 133, 585
- Flexure, modulus of elasticity, 198–199
- Floor fills, cellular concrete, 567
- Flowability, entrained air and, 478–479
- Flow cone, 69
- Flow test, 63
- Flow tester, 67
- Fluid grout characteristics, preplaced aggregate concrete, 593
- Fluid penetration coefficient, 245
- Fly ash, 7–8, 265
 - avoiding alkali-silica reactivity, 407
 - bleeding and, 113–114
 - chemical composition, 457
 - chemical requirements, 499–500
 - classification, 499
 - compatibility with slag, 526
 - controlling alkali-silica reaction, 505–506
 - fineness, 233
 - fire resistance and, 276
 - history and use, 496–499
 - loss on ignition, 499–500
 - optional chemical requirements, 500–503
 - physical requirements, 503–505
 - preplaced aggregate concrete, 591
 - sampling, 18
 - specification, 497–498
 - sulfate resistance and, 260–261
- Foam, preformed, cellular concrete, 562–563
- Fogging, 468
- Free moisture, in concrete, 174
- Freezing and thawing
 - damage, mechanism and air content, 289–290
 - dilation methods, 160–161
- durability air entrainment, 73
 - air-void system, 476
 - slag effect, 524
- lightweight aggregate concrete, 557
- petrographic examination and, 212
- rapid tests, 157–160
 - criticism, 158
 - degree of saturation, 159–160
 - effect of container, 159
 - use of salt water, 160
 - which deterioration measure to use, 158
- resistance to, 239
 - cellular concrete, 566
 - polymer-modified concrete and mortar, 610
 - recycled concrete, 396
 - roller-compacted concrete, 600–601
- scaling resistance, 161–162
- testing, 157, 358–359
- see also* Weathering
- Fresh concrete
 - air-void system, versus hardened concrete, 299
 - determining air voids, 480
 - factors influencing entrained air, 476–480
 - function of entrained air, 475–476
 - rheology, 40–41
 - sampling, 19–20
 - slag effect on properties, 517–519
- Friable particles, 360
 - petrographic evaluation, 379
 - tests for, 361
- Frictional properties, aggregates, 372–373
- Frost resistance
 - aggregates, 290
 - air content and, 289
 - entrained air, 475
- Frying pan moisture test, 353
- G**
- Galvanic current, calcium chloride and, 176–177
- Galvanized corrugated steel sheets, 178
- Galvanized reinforcing steel, 169
- Gas diffusion, 243
- Gas flow, transport test methods, 242–243
- Gel-space ratio theory, 46
- German impact test, 367
- Gillmore test, 440
- Glass
 - embedded, 179
 - reactive, 387
 - as recycled concrete contaminant, 397
 - volcanic, 395
- Grab sample, 17–18
- Grading, 337–340
 - aggregates, 339–340, 597–598
 - air entrainment and, 340

Grading (*continued*)

- definition, 337
 - lightweight aggregates, 550–551
 - significance, 338–339
 - specifications, 340
 - test method, 337–338
- Graphical recorders, 540
- Gravel, petrographic evaluation, 384, 386–387
- Gravimetric method, air content measurement, 77–78
- Greening, 524–526
- Ground-granulated-blast-furnace slag, sampling, 18–19
- Ground penetrating radar, 321–322
- Grout
- cement content analysis, 311
 - determining consistency, 69
 - fluidifier, preplaced aggregate concrete, 592
 - mix proportions, preplaced aggregate concrete, 592
 - mixtures, cellular concrete, 563
 - surface monitoring, preplaced aggregate concrete, 593
 - latex-modified, 614
 - mix proportions, preplaced aggregate concrete, 592
 - mixtures, cellular concrete, 563
 - packaged dry mixtures, 633
 - surface monitoring, preplaced aggregate concrete, 593
- Grout consistency meter, 69
- Gypsum
- in cement hydration, 7
 - in sulfate attack, 257

H

- Half-cell potential surveys, 170
- Hard core/soft shell microstructural model, 47
- Hardened cement paste, water movement, 240–241
- Hardened concrete, 309–312
- aggregate determination, 311
 - air-void system, 299–300
 - ASTM C 1084, 310–311
 - calcium oxide analysis, 310
 - cement type analysis, 310–311
 - chemical analysis, 309
 - density, determination, 303
 - determination of additives and admixtures, 311
 - determining air voids, 480–481
 - examination, 411
 - function of entrained air, 475–476
 - instrumental methods of analysis, 312
 - maleic acid analysis, 310
 - microscopic analysis of aggregates, 388
 - modeling degradation and service life, 47

- petrographic evaluation, 310, 411
 - aggregates, 383–384
 - polymer-modified concrete and mortar, 609–613
 - porosity, 239
 - preplaced aggregate, 594
 - properties, 14, 46–47
 - proportions of coarse and fine aggregates, 383–384
 - sample, 310
 - sampling, 20
 - water content, determination, 311–312
 - see also* Air content; Bleeding; Non-destructive tests; Time of setting
- Hardening reactions, microstructure, 8–9
- Hardness
- aggregates, 371–372
 - mixing water, 465
- Heat evolution, portland cement paste, 6–7
- Heat generation, 234
- Heat of hydration, 232–233, 441–442
- hydraulic cements, 441–442
 - reduction, slag effect, 521–523
- Heat release, 45–46
- Heavyweight aggregate concrete, high temperatures, 285
- High paste method, 599
- High-range water reducer, 66, 168–169, 486
- ready-mixed concrete, 537, 542
 - self-consolidating concrete, 639
- High temperature and pressure accelerated curing method, 146–147
- High temperatures
- aggregate concrete, 285
 - behavior mechanisms, 282–283
 - compressive strength and, 278–279
 - coupled with air blast, 285–286
 - determining thermal properties, 280
 - diffusivity, 280–281
 - effect on
 - creep, 280
 - modulus of elasticity, Poisson's ratio, and bulk modulus, 279–280
 - flexural strength and, 279
 - mechanical properties and, 278
 - moisture content influence, 282–284
 - refractory concrete, 285
 - spalling and cracking, 283–284
 - thermal conductivity, 280–281
 - thermal cycling, 282
 - thermal volume change, 281–282
 - very high strength concrete, 285
 - see also* Fire resistance Hooke's law, 194, 196, 203
- Hydrating cement pastes, isothermal calorimetry curve, 92
- Hydration, 41–43
- early reactions, 6–8
 - new concrete surfaces, 472

- portland cement, 452–453
 - products, 254–256
 - volume change, 215–216, 219, 221
- Hydration controlling admixtures, 489
- Hydration shells, 6–8
- Hydraulic activity, effect of slag, 517
- Hydraulic cement, 435–448, 450–460
- activity index, 437–438
 - air content, 446–447
 - alkali-silica reactivity, 447–448
 - blended, 456
 - chemical analysis methods, 457–458
 - consistency, 439–440
 - definition, 5
 - density, 436
 - durability, 446–448
 - fineness, 438–439
 - heat of hydration, 441–442
 - microscopic techniques, 459
 - optimum sulfate content, 446
 - performance-based specifications, 456–457
 - quantitative phase analysis, 459
 - quantitative x-ray diffraction, 459–460
 - sampling, 18
 - selective dissolution, 458
 - set, 440–441
 - strength, 444–446
 - sulfate reaction, 447–448
 - volume change, 442, 444
 - x-ray fluorescence, 458
 - see also* Portland cements
- Hydraulic pressure theory, 156
- Hydrogen bonding, 5–6
- HYMOSTRUC model, 42

I

- IBB rheometer, 70
- Ice formation, at frozen surfaces, 14
- Image analysis techniques, air-void system, 298–299
- Impact testing, fiber-reinforced concrete, 587
- Impulse response method, 320
- Impurities, in mixing water, 463–464
- Indices of precision, 26
- Industrial cinders, petrographic evaluation, 394
- Infrared spectroscopy, hardened concrete, 312
- Infrared-thermographic techniques, 320–321
- Insoluble residue, portland cement, 454
- Inspection by variables, 23
- Insulating concrete, thermal conductivity, 227, 229
- International Cement microscopy Association, 207
- Interparticle forces, 6
- Intrinsic permeability coefficient, 245
- Ionic diffusion, 245–247

- Ionizing electromagnetic waves, 571
- Iron blast furnace, 515
- Irradiation effects, 574–575
- ISO 9002, 54
- ISO/IEC 17025, 52, 54
- Isothermal calorimetry curve, hydrating cement pastes, 92
- J**
- J-ring, 644
- JSCE-SF4, 584, 586
- JSCE-SF5, 584
- JSCE-SF6, 584
- JSCE-SF7, 581–582
- K**
- Kelly ball test, 67
- K-slump tester, 67
- Kurtosis, 23
- L**
- Laboratory technicians
 - certification, 543
 - competency, 54
- Laser diffraction method, 39
- Latex
 - adhesives, organic materials, 625–626
 - coatings, 629–630
 - formulating with, 607–608
 - modification mechanism, 606–607
 - permeability and, 168
 - types, 605–606
- L-Box, 643
- Leaching, 254–256
 - soft water and, 264
- Lead, embedded, 177
- Le Chatelier's method, 221–222
- Length-diameter ratio, compressive strength and, 131–132
- Light elements, 571
- Light microscopy, hydraulic cement, 459
- Lightweight aggregate concrete, 548–559
 - abrasion resistance, 558
 - admixtures, 553
 - air content, 553
 - cellular concrete, 562
 - classification, 548–549
 - compressive strength, 555–556
 - contact zone, 557–558
 - creep, 556–557
 - density, 554
 - durability, 557
 - field adjustments, 554
 - field tests, 557
 - fire resistance, 558–559
 - high temperatures, 285
 - insulating, 548
 - modulus of elasticity, 556
 - petrographic evaluation, 394–395
 - properties, 554–557
 - proportioning, 552–553
 - resistance to alkali-aggregate reactions, 558
 - sampling, 554
 - shrinkage, 556
 - specifications, 559
 - specified density, 554–555
 - structural, 548
 - tensile strength, 556
 - see also* Cellular concrete
- Lightweight aggregates
 - absorption characteristics, 551–552
 - classification, 548–549
 - coarse, cellular concrete, 562
 - internal curing, 553–554
 - internal structure, 549
 - properties, 549–552
 - sampling, 554
- Lignite, 360–361
- Linear transverse method, air content, 295–296
- Liquid displacement techniques, 239
- Liquid membrane-forming curing compounds, 469–470
- Lithium, suppressing alkali-silica reaction, 408, 487
- Loading
 - direction, compressive strength and, 132
 - flexural strength, 135
 - rate, compressive strength and, 132
 - splitting tensile strength and, 136
- Los Angeles abrasion, 366–368
- Loss on ignition
 - fly ash, 499–500
 - portland cement, 454
- Low-alkali cement, 456
- M**
- Magnesium oxide
 - content, fly ash and natural pozzolan, 500–501
 - expansion due to hydration, 219, 221
 - portland cement, 454
- Magnesium sulfate reaction, 258
- Magnetic rebar locator, 170
- Magnetite, 166
- Maleic acid, analysis, 310
- Mass concrete, heat reduction, slag effect, 521–523
- Materials characterization, importance, 39–40
- Mathematical models, bleeding, 119, 121
- Maturity, 249
- Maturity functions, 330
- Maturity index, 149
- Maturity method, 136, 149–152, 330–331
 - application, 150–151
 - interpretation of results, 151–152
- new concrete surfaces, 472
- precautions, 152
- strength-maturity relationship, 150
- Maximum density method, 599
- Mean, arithmetic, 23
- Mechanical properties, high temperature and, 278
- Mercury intrusion porosimetry, 239–240
- Metakaolin, avoiding alkali-silica reactivity, 408
- Metallic contaminants, recycled concrete, 396–397
- Metals, embedded, *see* Corrosion, reinforced steel; Embedded materials
- Microcracking, 125–126
 - high temperatures and, 282
- Micro-Deval test, 369–370
- Micro-fillers, 285
- Microscopic techniques, hydraulic cement, 459
- Microstrain, 215
- Microstructure
 - hardening reactions, 8–9
 - mathematical modeling, 14
- Micro texture, 373
- Microwave oven drying, water content determination, 64
- Mid-range water reducing admixtures, 486
- Mill certificate, 18
- Mineral admixtures
 - definitions, 495
 - recycled concrete, 396
- Mineral deposits, cause, 255
- Minerals, to enhance radiation shielding attributes, 573
- Miner's rule, 138
- Mini-volumetric air meter, 62
- Mixer, uniformity, 19, 61
- Mixing
 - air entrainment and, 479
 - roller-compacted concrete, 601
 - self-consolidating concrete, 641
 - shotcrete, 621–622
 - uniformity testing, ready-mixed concrete, 542
- Mixing water, 462–466
 - algae in, 465
 - batching and measuring materials, 539
 - hardness, 465
 - impurity effect, 463–464
 - mixer wash, in ready-mixed concrete, 536–537
 - polymer-modified concrete and mortar, 608
 - ready-mixed concrete, 536
 - seawater, 464–465
 - shotcrete, 619–620
 - specification, 462–463

Mode, ideal, 39

Models

- degradation and service, hardened cement and concrete, 47
- time of setting, 97
- using real-shape aggregates, 39–40

Modified point-count method, air content, 296

Modulus of elasticity

- cellular concrete, 566
- in compression, 196–198
- high temperature and, 280
- lightweight aggregate concrete, 556
- static, 197
- in tension and flexure, 198–199

Mohr failure envelope, 137

Moisture clog spalling, 284

Moisture condition

- flexural strength and, 135
- specimen, compressive strength and, 132

Moisture content, high temperature behavior and, 282–284

Molded specimens, 81

- strength testing, 127

Monitoring, continuous evaluation, 27–28

Mortar

- aggregate size requirements, 339
- bleeding capacities, 101, 103
- cement content analysis, 311
- packaged dry mixtures, 632
- polymer-modified, applications, 613
- see also* Polymer-modified concrete and mortar

Mortar bar method, 405–406

Mortar flaking, bleeding and, 109

MTO LS-614, 358

N

Nailability, cellular concrete, 567

National Voluntary Laboratory Accreditation Program, 54

Neat-cement cellular concrete, 562

Neutron attenuation, 572

New concrete surfaces

- applied silicates, 471
- bond breakers, 471
- curing, 469–473
- dry shake hardeners, 471
- effectiveness of curing, 467–468
- hydration research, 472
- maturity testing, 472

NMR, time of setting, 97

Nondestructive tests, 314–331

- combined methods, 331
- echo method, 319–320
- ground penetrating radar, 321–322
- impulse response method, 320
- infrared-thermographic techniques, 320–321
- in-place strength testing, 136–137

maturity method, 330–331

pin penetration test, 328

probe penetration test, 324–328

pulloff tests, 331

pullout test, 328–330

pulse velocity method, 317–319

rebound method, 322–324

resonant frequency methods, 314–317

shotcrete, 622–623

spectral analysis of surface waves method, 320

stress wave propagation methods, 319–320

surface hardness methods, 322–328

Nonparametric tests, 28

Nonplastic mixtures, 12–13

No-slump concrete, measuring consistency, 68–69

Nozzles, shotcrete, 619

NT Build 443, 246

NT Build 492, 247

Nuclear methods, 64

Nuclear particles, 571–572

Nuclear-shielding properties, 302

Nurse-Saul maturity function, 330

O

Oils, oxidation and chemical attack, 266

Operating characteristics, 22

Operator subjectivity, air content testing, 298

Organic impurities, test for, 362

Organic materials, 625–630

bituminous coatings, 628–630

bonding and patching materials, 625–626

epoxy resins, 626–628

sealers, 630

Orimet, 643

Osmotic pressure hypothesis, 156

Overlying materials, epoxy resins, 626–628

Oxides, chemist's shorthand, 451

P

Packaged, dry, cementitious mixtures, 631–636

applications, 634–635

ASTMC 1107, 633

ASTM C 387, 632

ASTM C 928, 632–633

availability, 635

future needs, 635–636

hazardous considerations, 631

packaging, 635

quality control, 635

rejection of product, 635

specifications, 631–633

use of, 633–635

Paint

- abrasion resistance and, 187
- maintenance, latex-modified, 614

Particles

- condition, petrographic evaluation, 382–383
- shape, 39–40, 549
- size distribution, 41–42

Paste-aggregate bond, bleeding and, 106–107

Paste-aggregate interface, strength, 127

Paste content, effect on density, 304

Paste-steel bond, bleeding and, 107

Patching materials, 625–628

Pavement

- roller-compacted concrete, 596, 601
- thickness measurement, ground penetrating radar, 322
- strength, 80
- wear testing, 373

Penetration methods, *see* Time of setting

Penetration resistance data, time of setting, 87–88

Percolation plots, 43–44

Periclase, expansion due to hydration, 219, 221

Perlite, petrographic evaluation, 395

Permeability

- aggregates, 12
- cement paste, 11–12
- decreasing, 168
- density, 301
- hardened cement, slag effect, 519–520
- polymer-modified concrete and mortar, 610–613
- relationship with porosity, 247–250
- roller-compacted concrete, 600

Permeability coefficients, 11

Petrographers, qualifications, 377–378

Petrographic evaluation, 207–213

acceptability, 211

age of concrete under study, 210

aggregates, 377–398, 404–405, 410

contamination detection, 379

correlation of samples with aggregates previous tested, 378–379

determining processing effects, 379–380

establishing properties and performance, 378

hardened concrete, 383–384

natural, 384, 386–387

observations included in, 381–382

particle condition, 382–383

performance, 380–381

preliminary determination of quality, 378

purpose, 378–380

selecting and interpreting other tests, 379

alkali-reactive carbonate rocks, 413–415

- approach, 209–210
- blast-furnace slag, 392–394
- cement content, 310
- clay lumps, 379
- composition, 210–211
- concrete exposed to freezing and thawing, 212
- crusted stone, 390–392
- dolomitic carbonate rocks, 421
- environment effect, 211–212
- friable particles, 379
- hardened concrete, 411
- lightweight concrete aggregates, 394–395
- methods, 208–209
- observations, 210
- purpose, 209
- reconstruction of history of field concrete, 210
- recycled concrete, 395–398
- responsibilities, 208
- for soundness, 359–360
- source of concrete, 210
- texture, 210
- Petrography, 207–208
- Phase composition, portland cement, 451
- Pin penetration test, 328
- Placement
 - self-consolidating concrete, 641–642
 - size and height, bleeding and, 116–117
- Placing, bleeding and, 106
- Plastic concrete, bleeding and, 102–106
- Plasticizers, bleeding and, 115–116
- Plastics, embedded, 180
- Plastic shrinkage, 104–106, 215
- Poiseuille-Hagen law, 247
- Poisson's ratio, 195, 200, 315–316
 - high temperature and, 280
- Polishing, aggregates, 372–373
- Polymer-modified concrete and mortar, 605–615
 - abrasion resistance and, 186
 - aggregates, 608
 - applications, 613–614
 - cellular concrete, 563
 - cement, 607
 - equipment considerations, 614
 - latex
 - formulating with, 607–608
 - modification mechanism, 606–607
 - types, 605–606
 - limitations, 614
 - modifiers, 608
 - polymer modifiers, 608
 - properties, 609–613
 - air void system, 609
 - bond, 609–611
 - freeze-thaw resistance, 610
 - fresh, 609
 - permeability, 610–613
 - strain capacity, 613
 - proportioning, 608
 - shotcrete, 620
 - specifications, 615
- Pores
 - aggregates, 350–351
 - size distributions, 249
 - systems, characterizing, 249–250
- Pore water, capillary tension, 9
- Porosity, 9, 238–240
 - aggregates, 12
 - formed during concrete production, 239
 - hardened concrete, 239
 - measurement, 239–240
 - relationship with permeability, 247–250
- Portland cement
 - alkali sulfates, 460
 - Bogue calculations, 451–452
 - calcium sulfate, 459–460
 - carbonate, 459
 - cement content analysis, 311
 - cement phases and performance, 453
 - chemical composition, 450–451
 - chemical properties, 450–453
 - chemical requirements, ASTM C 150, 453–455
 - degree of hydration, 42
 - dry, 631
 - hydration reactions, 232, 452–453
 - insoluble residue, 454
 - loss on ignition, 454
 - magnesium oxide, 454
 - optional chemical requirements, 455–456
 - performance versus prescriptive standards, 460
 - phase composition, 451
 - roller-compacted concrete, 597
 - substitute elements in clinker phases, 452
 - sulfur trioxide, 454–455
 - trace elements, 460
 - types, ASTM C 150 chemical requirements, 455
 - volume change, 221–222
- Portland cement paste
 - carbonation, 174
 - heat evolution, 6–7
- Postbleeding expansion, 103–104
- Powers' spacing factor, 475
- Powers's spacing factor, 293–294
- Pozzolan reaction, 9
- Pozzolans, 265
 - activity index, 437, 504
 - bleeding and, 114
 - chemical composition, 457
 - controlling alkali-silica reaction, 505–506
 - natural
 - chemical requirements, 499–500
 - classification, 499
 - history and use, 496–499
 - optional chemical requirements, 500–503
 - physical requirements, 503–505
 - raw or calcined natural, avoiding alkali-silica reactivity, 408
 - roller-compacted concrete, 597
 - sampling, 18
 - strength index, 503–504
 - sulfate resistance and, 260
- Precast concrete, 567–568, 575
- Precision, 296–297
 - acceptance testing, 26–27
 - chemical analysis of hydraulic cement, 458
 - limit, 28
 - sulfate soundness test, 356–357
- Preformed foam, cellular concrete, 562–563
- Premature stiffening, test for, 440
- Preplaced aggregate concrete, 591–594
 - aggregates, 592–593
 - cementing materials, 591
 - compressive strength, 593
 - density, 594
 - fluid grout characteristics, 593
 - grout fluidifier, 592
 - grout mix proportions, 592
 - grout surface monitoring, 593
 - hardened, 594
 - radiation shielding, 576
 - temperatures at time of grout injections, 593
 - time of setting, 594
- Pressure meter, 75
- Prestressed concrete, corrosion, 169–170
- Prestressing force, loss, 203
- Prewetting, lightweight aggregates, 553
- Probe penetration test, 324–328
 - advantages and disadvantages, 327–328
 - versus core testing, 327
- Production control, workability, 60–61
- Proportioning, 12–13
 - abrasion resistance, 185
 - cellular concrete, 563
 - lightweight aggregate concrete, 552–553
 - polymer-modified concrete and mortar, 608
 - roller-compacted concrete, 598–599
 - self-consolidating concrete, 640–641
 - shotcrete, 620–621
 - workability and, 66
- Proton attenuation, 572–573
- Proton magnetic resonance, 472
- Pulloff tests, 331
- Pullout test, 136, 328–330
 - standardization, 329–330
- Pulse velocity method, 317–319
 - standardization, 318–319
- Pumice, petrographic evaluation, 394–395

Q

Quality, preliminary determination, 378
 Quality assurance
 shotcrete, 622
 supplementary cementitious materials, 507
 Quality control
 cellular concrete, 568
 packaged, dry, cementitious mixtures, 635
 roller-compacted concrete, 602–603
 self-consolidating concrete, 643–644
 slag, 514–515
 uniformity, tests, 61–63
 Quantitative phase analysis, hydraulic cement, 459
 Quantitative x-ray diffraction, hydraulic cement, 459–460
 Quarry sampling, alkali-carbonate rock reactivity, 421–422
 Quartz, fire and, 277
 Quick set, 7

R

Radiation shielding, 570–576
 absorption cross section, 573
 atomic structure and physics, 570–572
 concrete materials, 573–575
 density, 574
 irradiation effects, 574–575
 mechanics, 572–573
 physical and biological perspective, 572
 placement and verification, 575
 preplaced-aggregate concrete, 576
 scattering cross section, 573
 temperature effects, 575
 terms for design calculations, 573
 Radioactivity, recycled concrete, 396
 Radon gas, 572
 Range, 23
 Rapid chloride permeability, 47, 246–247
 Ready-mixed concrete, 533–545
 aggregates, 539
 air-entraining admixtures, 538
 air void system, 538
 approval of mixtures, 536
 basis of purchase, 534–535
 batching and measuring materials, 538–539
 batching plant, 539–540
 compressive strength testing, 543–544
 control of water addition, 542–543
 failure to meet strength requirements, 544
 high-range water reducers, 537, 542
 history of industry, 533
 hydration stabilizing admixtures, 537

 mixer wash water, 536–537
 mixing operations, 540–542
 mixing, placing, and curing, 553–554
 mixing uniformity testing, 542
 ordering information, 535–536
 recorders, 540
 returned concrete, 537
 sampling, 543
 slump and air content, 537–538
 specifications, 534
 testing laboratories, 543
 truck mixer hold back, 534–535
 volumetric concrete mixers, 543
 water-cementitious materials ratio, 535
 water quality, 536
 yield, 534
 Rebound method, 322–324
 Recycled concrete, 395–397
 Refractory concrete, high temperatures, 285
 Refractory shotcrete, 618
 Regression lines, 24
 Reinforced steel, *see* Corrosion, reinforced steel
 Reinforcing bars, shotcrete, 620
 Rejectable quality level, 22
 Relative density, aggregates, 349–350, 549
 Relative humidities, 9
 Relaxation, 201–203
 Remixing, bleeding and, 118
 Remolding test, 67
 Representative sample, 25
 Residual stress, calculations, 203–204
 Resonant frequency methods, 157, 314–317
 damping properties, 316
 dynamic modulus of elasticity, 314–316
 limitations and usefulness, 316–317
 other methods, 316
 standardization of methods, 316
 Returned concrete, reuse, 537
 Reusable molds, 81
 Revibration, bleeding and, 117–118
 Revolving-disk abrasion test machine, 188–189
 Rewetting, micro structure effects, 9
 Rheological methods, time of setting, 96–97
 Rheologic properties, 201–204
 Rheology
 cement paste, 10
 fresh cement and concrete, 40–41
 Rheometers, 70
 Rice husk ash, bleeding and, 114
 Ring test, fiber-reinforced concrete, 588
 Rock cylinder expansion test, 420–421
 Roller-compacted concrete, 545–603
 advantages, 596–597
 aggregates, 597–598
 air-entraining admixtures, 598

 cementitious materials, 597
 construction, 601–602
 curing, 602
 dams, 595–596
 definition, 595
 hardened, properties, 600
 pavement, 596
 placement, 601
 proportioning, 598–599
 quality control, 602–603
 water-reducing and retarding admixtures, 598
 Roller-compacted dam method, 599
 Roof deck fills, cellular concrete, 567
 Rotating-cutter drill press, 190
 Roundness, 340–342

S

Salt attack, 266–267
 Salts, dissolved, effect on lime dissolution, 255
 Sample
 preparation, hardened concrete, 310
 selection, hardened concrete, 310
 size, 25
 unit, 17
 see also Specimens
 Sampling, 16–17
 air content, 74, 297
 contamination, 18
 determination of uniformity, 19
 fresh concrete, 19–20
 fresh fiber-reinforced concrete, 579
 hardened concrete, 20
 lightweight aggregates, 554
 ready-mixed concrete, 543
 statistical considerations, 24–25
 Sand
 petrographic evaluation, 384, 386–387
 workability and, 65
 Sandblasting, abrasion testing, 187
 Sanded cellular concrete, 562
 Saturated flow, test methods, 245
 Saturated steam conditions, 283
 Saturation index, 255
 Sawability, cellular concrete, 567
 Sawed specimens, strength testing, 127–128
 Scaling, 156, 254–256
 bleeding and, 108–109
 resistance, 161–162, 610
 slag effect, 524
 Scanning electron microscopy, hardened concrete, 312
 Scattering cross section, radiation shielding, 573
 Scoria, petrographic evaluation, 394–395
 Sealers, organic, 630
 Sealing compounds, 629
 Seawater, 265–266
 mixing water, 464–465

- Sedimentation, 7
- Self-consolidating concrete, 637–644
 - admixtures, 639
 - advantages, 638–639
 - aggregates, 639
 - applications, 638
 - batching and mixing, 641
 - definition, 637
 - environmental benefits, 638–639
 - finishing and curing, 642
 - hardened, properties, 642–643
 - history, 637–638
 - placement, 641–642
 - proportioning, 640–641
 - quality control, 643–644
 - supplementary cementitious materials, 639
 - transporting, 641
 - workability, 69–70
- Self-desiccation, 216
- Self-leveling flooring materials, 636
- Service life
 - modeling, 47
 - strategies to improve, 254
- Set, hydraulic cements, 440–441
- Set-retarding admixtures, 484–485
- Setting, *see* Time of setting
- Sewer lines, acid attack, 264
- Shale, petrographic evaluation, 394
- Shape, 340–342
 - aggregates, 347–348
 - petrographic evaluation, 383
- Shear strength, cellular concrete, 566
- Shear stress, 195–196
- Sheet materials, curing, 469
- Shotcrete, 616–623
 - ACI and, 617
 - applications, history, 619
 - ASTM and, 617–618
 - batching and mixing, 621–622
 - definition, 616–617
 - dry-mixture, 621
 - equipment, 619
 - fiber-reinforced, 618
 - history, 618–619
 - latex-modified, 614
 - materials, 619–620
 - nozzles, 619
 - prepackaged, 636
 - properties, 617
 - proportioning, 620–621
 - quality assurance, 622
 - refractory, 618
 - testing, 622–623
 - wet-mixture, 621
- Shrinkage
 - lightweight aggregate concrete, 556
 - slag effect, 523–524
- Shrinkage-reducing admixtures, 488
- Shrink mixing, ready-mixed concrete, 541
- Sieve stability, self-consolidating concrete, 644
- Silane, 169, 630
- Silica fume, 7, 9, 265, 507–508
 - avoiding alkali-silica reactivity, 408
 - batching, 538
 - bleeding and, 114
 - chemical composition, 457
 - chemical requirements, 507–508
 - compatibility with slag, 526
 - drying shrinkage, 219
 - fire resistance and, 276
 - history and use, 507
 - permeability and, 169
 - physical requirements, 508
- Silicates, applied to new concrete
 - surfaces, 471
- Single-use mold, 81
- Skewness, 23
- Skid-resistant coatings, polymer-modified concrete and mortar, 613
- Slag, 9, 512–528
 - activity index, 437, 514
 - blast-furnace
 - expanded, petrographic evaluation, 394
 - petrographic evaluation, 392–394
 - bleeding and, 114
 - blended cement, 515
 - chemical requirements, 514
 - compatibility with
 - aggregates, 526
 - chemical admixtures, 526
 - supplementary cementitious materials, 526–527
 - composition, 516–517
 - compounds in, 392–393
 - definition, 512
 - effect on fresh concrete properties, 517–519
 - effect on hardened concrete properties, 519–526
 - effect on hydraulic activity, 517
 - environmental benefits, 527–528
 - fineness, 514
 - fire resistance and, 276
 - grades, 514
 - ground granulated blast-furnace
 - avoiding alkali-silica reactivity, 408
 - chemical composition, 457
 - history, 512–513
 - production, 515
 - quality control, 514–515
 - specifications, 513–515
 - sulfate resistance and, 260
 - U. S. cement use, 513
- Slate, petrographic evaluation, 394
- Slump
 - rate of loss, 542
 - ready-mixed concrete, 537
- Slump flow test, self-consolidating concrete, 643
- Slump test, 61–62, 66–67
- Slurry mixtures, cellular concrete, 563
- Sodium sulfate reaction, 258
- Soft particles, testing for, 361–362
- Solid-phase admixtures, sampling, 19
- Soniscope, 317
- Soundness, 356–360
 - absorption tests, 358
 - definition, 355
 - petrographic examination for, 359–360
 - sulfate soundness test, 356–358
 - supplementary cementitious materials, 504
- Spacing factor, 293–294
 - air voids, 475
 - test result interpretation, 300
- Spalling, fire-damage, 283–284
- Specific gravity, aggregates, 12, 349
- Specific heat, 229
 - aggregates, 429
 - high temperatures and, 280–281
 - test methods, 429–430
- Specific surface
 - air-void system, 292–293
 - test result interpretation, 300
- Specified density concrete, 554–555
- Specimens, 80–85
 - applications, 80–81
 - dimensions, flexural strength and, 134
 - end conditions, compressive strength, 129–130
 - from existing structures, strength testing, 127–128
 - field curing, 83
 - length and diameter, splitting tensile strength, 135–136
 - making and curing, 82–83
 - in the field, 81–84
 - in the laboratory, 84
 - moisture condition
 - compressive strength and, 132
 - splitting tensile strength and, 135
 - molds, 81
 - samples derived from, 82
 - sizes, 82
 - compressive strength and, 130–131
 - creep and, 202
 - flexural strength and, 134
 - standard final laboratory curing, 83–84
 - standard initial curing, 83
 - test data, 82
 - testing personnel, 81
 - transporting, 83
 - uses, 81–82
 - see also* Sample
- Spectral analysis of surface waves
 - method, 320
- Speedy moisture test, 353
- Sphericity, 340–341
- Splitting tensile strength, 80, 133–136
- Spring coefficient, 194
- Standard deviation, 23

- Statistical considerations, 22–28
 - arithmetic mean, 23
 - coefficient of variation, 23
 - correlation coefficient, 23
 - difference two sigma limit, 23, 26
 - evaluation of test data, 26
 - inspection by variables, 23
 - kurtosis, 23
 - number of subsamples, 25
 - operating characteristics, 22
 - range, 23
 - regression lines, 24
 - sampling, 24–25
 - skewness, 23
 - standard deviation, 23
 - statistical parameters, 22–23
 - testing, 25–26
 - Statistical parameters, 22–23
 - Statistical uncertainty, air content, 297
 - Steel
 - embedded, fire and, 277–278
 - new, 171
 - Stockpiles, sampling, 17
 - Stoke's law, 247
 - Strain capacity, polymer-modified concrete and mortar, 613
 - Stratified random sampling, 25
 - Strength, 32, 125–138
 - aggregates, 370–371
 - cement paste, 126
 - effect of algae in mixing water, 465
 - fatigue, 137–138
 - flexural, 134–135
 - hardened cement, slag effect, 519
 - hardened concrete, bleeding and, 106–112
 - hardened fiber-reinforced concrete, tests, 584–587
 - hydraulic cements, 444–446
 - nature of, 125–127
 - paste-aggregate interface, 127
 - pavement concrete, 80
 - prediction at later ages, 141–152
 - accelerated curing methods, 141–149
 - compressive strength, 141–149
 - strength estimation, 147–149
 - rebound test method, 323–324
 - reduction, air content and, 289
 - relationships, 136
 - testing, 63, 80–81
 - evaluation, 28
 - nondestructive in-place, 136–137
 - purposes, 125
 - test specimen preparation, 127–128
 - variables affecting, 80
 - see also* Compressive strength
 - Strengthening, hardened fiber-reinforced concrete, 582–583
 - Strength index, pozzolan, 503–504
 - Stress, combined states, strength and, 137
 - Stress-strain curve, concrete, 126
 - Stress wave propagation methods, 319–320
 - Structural integrity, fire and, 277–278
 - Structure, design, improving service life, 254
 - Stucco, cement content analysis, 311
 - Studded tire wear, 373
 - Sub-bases, impermeable, bleeding and, 117
 - Sulfate attack, 215
 - external, 256–259
 - calcium sulfate reaction, 257–258
 - control, 259–261
 - magnesium sulfate reaction, 258
 - sodium sulfate reaction, 258
 - hydraulic cements, 447–448
 - internal, 257, 262
 - mitigation, slag effect, 520–521
 - thaumasite form, 259
 - Sulfate content, 309, 446
 - Sulfate corrosion, *see* Sulfate attack
 - Sulfate resistance
 - delayed ettringite formation, 257, 260, 262–263
 - effect of chlorides, 259
 - tests, 261–262
 - Sulfate soundness test, 356–358
 - Sulfoaluminate attack, 257
 - Sulfur mortar, capping technique, 129–130
 - Sulfur trioxide, portland cement, 454–455
 - Superplasticizers, 10
 - Supplement, definitions, 495–496
 - Supplementary cementitious materials, 9, 495–504
 - air entrainment, 479
 - ASTM C 94, 538–539
 - batching and measuring materials, 538–539
 - bleeding and, 113–114
 - cellular concrete, 563
 - compatibility with slag, 526–527
 - definitions, 495–496
 - drying shrinkage, 505
 - fineness, 503
 - fundamental properties, 496
 - optional physical requirements, 505–506
 - quality assurance, 507
 - self-consolidating concrete, 639
 - shotcrete, 619
 - soundness, 504
 - test requirements not in specifications, 506–507
 - see also* Fly ash; Pozzolan; Silica fume
 - Surface appearance, bleeding and, 111–112
 - Surface hardness methods, 322–328
 - pin penetration test, 328
 - probe penetration test, 324–328
 - rebound method, 322–324
 - Surface moisture, aggregates, 352–353
 - Surface preparation, air content specimens, 298
 - Surface sealer, 169
 - Surface texture, 342–343
 - aggregates, 347–348, 549
 - Surface treatment, abrasion resistance and, 187
 - Sweating, *see* Bleeding
 - Swelling, 216
 - Synthetic-resin coatings, 629
- ## T
- Temperature
 - air entrainment and, 479
 - workability and, 63
 - radiation shielding, 575
 - Temperature-matched curing technique, 127
 - Temperature measurement, 73–74
 - Temperature rise, 234
 - Tensile creep, measurement, 202
 - Tensile strength, 80
 - cellular concrete, 565
 - lightweight aggregate concrete, 556
 - splitting, 133–134
 - test procedures, 133–134
 - Tension, modulus of elasticity, 198–199
 - Testing
 - concerns, 51–52
 - continuing improvements in quality of, 53
 - shotcrete, 622–623
 - statistical considerations, 25–26
 - trends, 52–53
 - Testing laboratories, 51–54
 - evaluation authorities, 53–54
 - ready-mixed concrete, 543
 - technician competency, 54
 - Testing machine, characteristics, compressive strength and, 132
 - Testing personnel, 81
 - Texture, 210
 - Thaulow concrete tester, 68–69
 - Thaumasite, in sulfate attack, 257, 259
 - Thawing, *see* Freezing and thawing; Weathering tests
 - Thermal coefficient of expansion, 281, 427–428
 - Thermal conductivity, 226–227, 428
 - cellular concrete, 564–565
 - fire resistance of steel, 278
 - high temperatures, 280–281
 - test methods, 429–430
 - Thermal cracking, 284
 - Thermal cycling, high temperatures, 282
 - Thermal diffusivity, 229–230, 429–430
 - Thermal expansion, 230–232
 - aggregates, 426–427
 - cement paste, 12
 - Thermal incompatibilities, high temperatures, 281–282

- Thermal methods, time of setting, 92–94
- Thermal methods of analysis, hardened concrete, 312
- Thermal properties, 226–236
 - aggregate, 277, 425–430
 - analytical methods, 235–236
 - coefficient of thermal expansion, 426–427
 - determining, 280
 - heat flow, 234–235
 - heat generation, 234
 - heat of hydration, 232–233
 - restrained volume changes, 235
 - significance, 233–236
 - specific heat, 229, 429
 - test methods, 227–228, 429–430
 - thermal conductivity, 226–227, 428
 - thermal diffusivity, 229–230, 429
 - thermal expansion, 230–232
- Thermal shielding properties, 302
- Thermogravimetry tests, fire resistance, 276
- Third-point loading, flexural strength, 135
- Thixotropic mixtures, bleeding and, 106
- Time-domain-reflectometry microwave spectrometry, 472
- Time of setting, 43–44, 86–97
 - advantages, 88
 - computer modeling, 97
 - current ASTM method, 86–90
 - advantages, 88
 - basics, 86–87
 - data manipulation, 87–88
 - disadvantages, 88–89
 - modifications, 89–90
 - electrical methods, 95–96
 - fresh concrete, slag effect, 518
 - as function of punch location, 89–90
 - history, 86
 - NMR, 97
 - other penetration methods, 90–92
 - preplaced aggregate concrete, 594
 - rheological methods, 96–97
 - temperature versus time, 93–94
 - test result significance, 136
 - thermal methods, 92–94
 - ultrasonic methods, 94–95
 - virtual testing, 43–44
 - x-ray diffraction, 97
- Toughening, hardened fiber-reinforced concrete, 583–584
- Toughness, hardened fiber-reinforced concrete, tests, 584–587
- Trace elements, portland cement, 460
- Transition zone, 13
- Transport
 - mechanisms, 240–242
 - test methods, 242–247
 - chloride ingress, 245
 - gas, 242–243
 - ionic diffusion, 245–247
 - water, 243–245
- Transporting
 - roller-compacted concrete, 601
 - self-consolidating concrete, 641
 - specimens, 83
- Tricalcium aluminate, sulfate resistance and, 260
- Truck mixing, ready-mixed concrete, 541–542
- Truck slump meter, 68
- TT-C-800, 470
- Tuff, petrographic evaluation, 394–395
- Two-point workability tests, 70
- Type K expansive cement, 219–221
- U**
 - U-Box, 643
 - Ultrasonic concrete tester, 317
 - Ultrasonic methods
 - elastic modulus, 199–200
 - time of setting, 94–95
 - Underwater abrasion test method, 190–191, 368
 - Uniformity
 - concrete-making materials, 30–37
 - evaluation, 32, 36–37
 - evaluation of uniformity, 32, 36–37
 - as function of design and construction process, 30–31
 - standard for determining, 36–37
 - density, 301
 - determination, 19
 - measuring, 61–64
 - workability and, 60
 - USBR 4907, 229
 - USBR 4908, 230, 260, 262
 - USBR 4910, 232
 - USBR 4911, 233
 - U.S. Bureau of Reclamation, test of mixer performance, 61
- V**
 - VCCTL, 38
 - Vebe apparatus, 63, 68–69
 - Vermiculite, exfoliated, petrographic evaluation, 395
 - Very high strength concrete, high temperatures, 285
 - V-funnel, 643
 - Vibration, air entrainment and, 479–480
 - Vicat test, 441
 - Virtual Cement and Concrete Testing Laboratory, 38
 - Virtual testing, 38–48
 - adiabatic temperature rise, 45–46
 - chemical shrinkage, 44–45
 - definition, 38–39
 - future directions, 47–48
 - heat release, 45–46
 - laser diffraction method, 39
 - properties of hardened cement paste and concrete, 46–47
 - properties of hardening cement paste and concrete, 41–46
 - rheology of fresh cement and concrete, 40–41
 - setting time, 43–44
- Viscosity-modifying admixtures, 66, 488
- Visual survey, 170
- Voids
 - aggregates, 348–349
 - frequency, test result interpretation, 300
- Voids content, density, 301
- Volcanic cinders, petrographic evaluation, 394–395
- Volume change, 215–223
 - autogenous, 216
 - bleeding, 102–103
 - carbonation shrinkage, 216–217
 - concrete with reactive carbonate rocks, 415–417
 - delayed ettringite formation, 263
 - drying shrinkage, 217–219
 - expansion due to hydration of free CaO and MgO, 219, 221
 - expansive cement mortar and concrete, 219–223
 - length
 - alkali-carbonate rock reactivity, 411
 - due to alkali-silica reaction, 406
 - hydraulic cements, 442, 444
 - portland cement mortar and concrete, 221–222
 - restrained, 235
 - roller-compacted concrete, 600
 - swelling clay minerals, 361
 - test methods, 221–223
 - thermal, 230–232
 - fire and, 276–277
 - high temperatures and, 281–282
 - types, 215
- Volumetric concrete mixers, 543
- Volumetric method, air content measurement, 76–77
- Volumetric Mixer Manufacturers Bureau, 543
- W**
 - Wagner test, 438
 - Walkability, cellular concrete, 566–567
 - WATEQ model, 255
 - Water
 - absorption
 - aggregates, 351–352
 - cellular concrete, 566
 - air entrainment and, 478
 - for cellular concrete, 562
 - city, analysis, 463–464
 - in concrete, 5–6
 - curing, 465–466

- Water (*continued*)
 free, high temperatures and, 283
 lime-saturated, 255
 mixing, *see* Mixing water
 quality, ready-mixed concrete, 536
 transport test methods, 243–245
 volume of freezable, 290
- Water-cementitious materials ratio
 petrographic examination, 211
 ready-mixed concrete, 535
- Water-cement ratio, 9–10
 bleeding and, 106, 112
 sulfate resistance and, 261
- Water content
 basic, 12
 bleeding and, 112
 cement paste, drying shrinkage, 218, 220–221
 curing and, 470
 hardened concrete, determination, 311–312
 heat of hydration and, 232
 non-evaporable, cement phases, 43
 thermal conductivity and, 226–227
 uniformity, tests, 64
- Water gain, *see* Bleeding
- Water-immersion test method, 353
- Water penetration, test methods, 244–245
- Water-reducing admixtures, 10, 484–485
 bleeding and, 115
 workability and, 66
 roller-compacted concrete, 598
- Water-resistance basement coatings, polymer-modified concrete and mortar, 614
- Water retention, curing materials, 468
- Water-vapor diffusion, 243–244
- Wave reflection factor, 94–95
- Wear, aggregates, 372–373
- Weather conditions, bleeding and, 117
- Weathering
 other processes, 162
 tests, 154–155
 historical evolution, 155–156
 rapid freezing and thawing tests, 157–160
 theoretical considerations, 156–157
 see also Freezing and thawing
- Weeping, *see* Bleeding
- Wet degradation test, aggregates, 368–370
- Wick action, 245
- Wigmore consistometer, 68
- Willis-Hime method, 63
- Windsor probe test system, 324
- Wind velocity, bleeding and, 117
- Wood, embedded, 179–180
- Workability, 59–71
 aggregate size and, 339
 air content and, 62, 289
 ball penetration test, 67
 cellular concrete, 564
 cement content uniformity, 63–64
 definition, 64
 density test, 62–63
 entrained air and, 478–479
 factors affecting, 64–66
 fiber effect, 578
 flow test, 63, 67
 fresh concrete, slag effect, 517–518
 fresh fiber-reinforced concrete, 579–581
 grout consistency, 69
 mixer uniformity, 61
 normal consistency concrete, 66–68
 no-slump concrete, 68–69
 production control, 60–61
 properties involved in, 64
 quality control uniformity, 61–63
 recycled concrete, 396
 remolding test, 67
 self-consolidating concrete, 69–70
 strength testing, 63
 surface texture and, 342
 temperature and, 63
 terminology, 59–60
 truck slump meter, 68
 two-point tests, 70
 uniformity of concrete, 61
 Vebe apparatus, 63, 68–69
 water content uniformity, 64
 Wigmore consistometer, 68
- X**
- X-ray diffraction
 cement paste, 212
 hardened concrete, 312
 Rietveld analysis, 39, 42–43
 time of setting, 97
- X-ray fluorescence, hydraulic cement, 458
- Y**
- Yield
 air content and, 289
 data, 73
 fresh fiber-reinforced concrete, 581
 ready-mixed concrete, 534
 stress, cement paste, 10
- Young's modulus, 40, 194–195
 relation with rock type, 371–372
- Z**
- Zinc
 embedded, 178–179
 as galvanized coating for steel, 178
 as steel coating, 169