

Subject Index

A

- AASHTO Accreditation Program, 40
 AASHTO Materials Reference Laboratory, 40–41
 AASHTO T 259, 167–168
 AASHTO T 260, 171
 AASHTO T 277–83, 255
- Abrasion**
 definitions, 182
 test methods
 application, 190–191
 ASTM C 418, 186
 ASTM C 779, 186–188
 ASTM C 944, 188–189
 ASTM C 1138, 189–190
 types, 182
- Abrasion resistance, 182–190**
 aggregate quality and, 183
 compressive strength and, 183–184
 concrete types and, 184
 curing and, 185
 factors affecting, 182–185
 finishing procedures and, 184–185
 lightweight aggregate concrete, 531
 mixture proportioning and, 183–184
 surface treatment and, 185
- Absorption (see also Water, absorption)**
 characteristics, lightweight aggregates, 525
 method, cement content analysis, 113–114
 soundness tests, 414
- Absorption coefficient, 542**
- Absorption cross section, 542–543**
- Accelerating admixtures, 494–495**
- ACI 116, 182
 ACI 116R, 49
 ACI 116R–90, 491, 567
 ACI 117, 512
 ACI 207.5R, 571
 ACI 208–58, 202
 ACI 211, 59, 308
 ACI 211.1, 54, 75, 404, 595
 ACI 211.2, 75, 595
 ACI 212.3R, 491–492
 ACI 213, 531
 ACI 213R–87, 536
 ACI 214, 71, 73
 ACI 214–77, 53
 ACI 226.1R–87, 500, 506
 ACI 226.3R–87, 500
 ACI 228, 73
 ACI 304, 50, 596
 ACI 304.2, 596
- ACI 305R–89, 480
 ACI 306, 238
 ACI 306R–88, 480
 ACI 308, 74
 ACI 308–81, 481
 ACI 309.1R, 49
 ACI 310, 513
 ACI 318, 38, 272, 513, 531, 594
 ACI 318–63, 204, 206
 ACI 318–71, 204–205, 207
 ACI 318–89, 205–206
 ACI 503.1, 601
 ACI 503.2, 601
 ACI 503.3, 601
 ACI 503.4, 601
 ACI 506, 589–591
 ACI 506–66, 590
 ACI 506R, 594, 596
 ACI 506R–90, 593
 ACI 506.2, 596
 ACI 506.2–77, 590
 ACI 506.3R–82, 590
 ACI 523.2R, 536
 ACI 547R, 593
 ACI 805–51, 589–590
- Acid attack, 272–274**
- Acoustic properties, unit weight and, 309–310**
- Activity index, hydraulic cements, 451**
- Additives, content analysis, 318**
- Adhesives, 600–602**
- Admixtures (see also Chemical admixtures; Mineral admixtures; specific materials)**
 air-entraining, 299
 alkali-silica reactivity and, 370–371
 bonding and patching, 599–600
 content analysis, 318
 definitions, 491
 effects on permeability, 256
 proportioning, abrasion resistance and, 183–184
 ready mixed concrete, 515
 in recycled concrete, 359
 roller-compacted concrete, 571
 sampling, 19–20
 shotcrete, 594
- Adsorption, 247–248**
- Age**
 of cement paste, permeability coefficient and, 245
 of concrete, petrographic examination and, 214
- Aggregates (see also Lightweight aggregates; Petrographic evaluation, aggregates)**
- air voids, 422–423
 alkali-silica reactivity, 366–369
 as a whole, 388
 coarse
 degradation, 390–391
 grading, 402–404
 latex-modified mixes, 580
 particle size, workability and, 54
 pore system, 429–437
 preplaced aggregate concrete, 563
 size, effect on flexural strength, 132
 coatings, 407–408, 418–419
 concrete permeability and, 168–169
 configuration, 421–422
 content analysis, 318
 definition, 5
 degradation, impact on specifications, 398
 deleterious substances, 415–418
 drying shrinkage and, 222–223
 effect on
 bleeding, 104
 compressive strength, 287
 unit weight, 311
 elastic properties, 395
 fine
 entrained air and, 487
 grading, 404
 latex-modified mixes, 580
 preplaced aggregate concrete, 563
 fineness modulus, 401–402
 fire resistance, 283, 285
 frictional properties, 397–398
 frost resistance, 298
 grading, 401–405, 422
 hardness, 395–397
 heavyweight, 293
 high-density, preplaced aggregate concrete specification, 564
 lightweight, 293
 mobility, 421–422
 permeability, 246
 petrographic examination, 211
 properties, 11
 Poisson's ratio, 395
 porosity and permeability, 240–241
 quality, abrasion resistance and, 183
 in radiation shielding, 542
 ready mixed concrete, 515
 roller-compacted concrete, 570–571
 sampling, 19
 shape, 405–406, 421–422
 shotcrete, 593

612 TESTS AND PROPERTIES OF CONCRETE

- soundness, 412–415
 - specific gravity, 424–425
 - specific heat, 442
 - standards, 389
 - strength, 388–389, 394–395
 - surface moisture, 425–426
 - texture, 406–408, 421–422
 - thermal conductivity, 230, 441–442
 - thermal diffusivity, 442
 - thermal expansion, 233–234, 440–441
 - thermal properties, 438–443
 - water absorption, 423–424, 426–428
 - wear, 396–398
 - wet degradation and attrition tests, 391–394
 - wood, 178–179
- Aggregate-to-mortar bond, 395
- Air compressors, shotcrete, 592–593
- Air content (*see* Air voids)
- cohesion and, 297
 - consistency and, 487
 - effects of algae in mixing water, 475–476
 - fresh fiber-reinforced concrete, 550
 - frost resistance and, 297
 - hardened concrete, 296–300, 308
 - hardness effect on mixing water, 476
 - hydraulic cements, 458–459
 - measurement
 - hardened concrete, 300
 - fresh concrete, 65–66
 - methods, fresh concrete, 66–69
 - optimum, air-void parameters, 485
 - ready mixed concrete, 514
 - strength reduction and, 297
 - uniformity test, 51–52
 - unit weight and yield, 297, 311
 - water/cement ratio and, 487
 - workability and, 297
- Air-entraining admixtures, 484–489
- chemical, 487
 - current specifications and test results, 489
 - definitions, 484
 - determining air void characteristics, 488–489
 - entrained air, factors affecting amount and character, 486–488
 - fine aggregate, 487
 - hydraulic cements, 458
 - materials, 484–485
 - mixing action, 487–488
 - potential, cement content and, 487
 - roller-compacted concrete, 571
 - supplementary cementing materials, 487
 - temperature, 488
- Air entrainment
- grading effect on, 404–405
 - workability and, 54
- Air-free unit weight test, 50–51
- Air voids
- aggregates, 422–423
 - characteristics, 486, 488–489
 - composite gradation, 299–300
 - content analysis, 318
 - dispersion and spacing, 398, 301–302, 486
 - expulsion with vibration, 488
 - freeze-thaw damage and, 297–298, 486
 - frost resistance and, 298, 308
 - lightweight aggregates, 524–525
 - shape, 300
 - size, 486
- Air-void system
- geometry evaluation, 302–308
 - ASTM C 457 microscopic analysis, 302–303
 - comparing parameters in fresh and hardened concrete, 307
 - image analysis techniques, 307
 - linear traverse method, 303–304
 - modified point count method, 304
 - precision and bias, 304
 - sources of variability and uncertainty, 304–307
 - test result interpretation, 307–308
 - latex-modified portland cement, 581–582
 - specific surface, 300–301
 - with and without air-entraining admixtures, 298–299
- Akeley, Carl E., 591
- Algae, in mixing water, effects on air content and strength, 475–476
- Alite, 464
- Alkali-aggregate reaction, research needs, 45
- Alkali-carbonate rock reactivity, 372–386
- ASTM standards, 372–373
 - chemical and mineralogical composition, 378–379
 - compared with alkali-silica reaction, 375
 - distress manifestations, 374–375
 - evaluating potential for
 - autoclaved concrete microbars, 385
 - concrete prism expansion test, 382–383
 - determination by chemical composition, 384–385
 - field service record, 381–382
 - freeze-thaw in salt solution, 385
 - miniature rock prisms, 385
 - petrographic examination, 384
 - rock cylinder expansion test, 383–384
 - expansive dedolomization reaction, 373–374
 - mechanism of reaction and expansion, 381
 - petrographic characteristics, 375–378
 - quarry sampling, 385
 - types of reactions, 373
- Alkali reactivity, aggregate constituents of hardened concrete, 348
- Alkali-silica reactivity, 365–371
- admixed materials, 370–371
 - avoiding expansive reactions, 369–371
 - cement alkali level, 369–370
 - compared with alkali-carbonate rock reactivity, 375
 - fly ash, 504
 - hydraulic cements, 459
 - identifying potentially reactive aggregate, 367–369
 - mechanism of reactions and distress, 366–367
 - moisture availability and environmental effects, 367
 - mortar bar tests, 367–368
 - petrographic examination, 368
 - Quick Chemical Test, 368
 - rapid mortar-bar expansion test, 368–369
 - symptoms, 365–366
 - types of reactive aggregate, 366–367
- Alkali sulfates, hydraulic cements, 471
- Aluminate, 464–465
- Aluminum, corrosion, 174–176
- American Association of Laboratory Accreditation, 40
- Amino alcohol derivatives, 221
- Anti-corrosion agent, 169
- AS1342, 253
- Asbestos, corrosion, 180
- Aspect ratio, 547, 553
- effect on setting time, 128
- ASTM 117–90, 586
- ASTM A 185, 594
- ASTM A 305, 202, 204, 206
- ASTM A 305–56T, 202
- ASTM A 385, 594
- ASTM A 408, 204
- ASTM A 416, 594, 594
- ASTM A 421, 594
- ASTM A 497, 594
- ASTM A 615, 202, 204, 594
- ASTM A 616, 202, 594
- ASTM A 617, 202, 594
- ASTM A 641, 594
- ASTM A 706, 594
- ASTM A 722, 594
- ASTM A 767, 594
- ASTM A 775, 206, 594
- ASTM A 820, 547
- ASTM C 29, 423, 430, 523
- ASTM C 31, 71–75, 124–126, 137, 149, 151, 519, 575
- ASTM C 33, 54, 178, 180, 183, 299, 341, 359–360, 368, 372–373, 389, 396, 398, 401–402, 404–406, 408, 411, 414–417, 423, 459, 580, 591, 593, 595, 608–609
- ASTM C 39, 71, 125–126, 128–131, 137, 286, 519
- ASTM C 40, 26, 417
- ASTM C 42, 20, 125–126, 128, 330–331, 596–597
- ASTM C 70, 426
- ASTM C 71, 481
- ASTM C 78, 71, 130–132, 287
- ASTM C 85, 315–317
- ASTM C 87, 417
- ASTM C 88, 267, 353, 411–413, 415, 419
- ASTM C 91, 40, 609
- ASTM C 94, 20, 50–51, 53, 71–72, 473, 511–520, 596
- ASTM C 109, 33, 450, 452, 457–458, 506
- ASTM C 114, 468–469, 502
- ASTM C 115, 300, 450
- ASTM C 116, 125–126, 128, 130, 548, 550, 560
- ASTM C 117, 344, 408, 416–417
- ASTM C 123, 415, 417
- ASTM C 125, 5, 11, 53–54, 300, 347, 353–354, 403, 484, 500, 505
- ASTM C 127, 75, 414, 423–428, 432, 525
- ASTM C 128, 75, 414, 423–428, 525
- ASTM C 131, 183, 389–391, 415, 417
- ASTM C 136, 344, 401, 525
- ASTM C 138, 51, 69, 75, 297, 307–308, 488, 512, 550
- ASTM C 142, 342, 415–416
- ASTM C 143, 52, 55, 66, 72–73, 75
- ASTM C 144, 609
- ASTM C 150, 40, 107, 223–224, 226, 236, 270, 272, 317, 449, 462–463, 465–467, 471, 570, 589, 593, 609
- ASTM C 151, 224–226, 450, 456, 531
- ASTM C 156, 478, 481–482
- ASTM C 157, 225–227, 450, 452, 455, 529, 559
- ASTM C 171, 594, 596
- ASTM C 172, 20, 66, 73, 527, 548, 550
- ASTM C 173, 51–52, 68, 73, 75, 307, 486, 526, 527, 550
- ASTM C 177, 231, 288, 443, 523, 534
- ASTM C 183, 20, 26
- ASTM C 184, 450
- ASTM C 185, 450, 452, 459
- ASTM C 186, 235, 450, 455
- ASTM C 187, 453, 450, 452
- ASTM C 188, 432, 450–451, 524
- ASTM C 190, 457
- ASTM C 191, 450, 453–454
- ASTM C 192, 71–73, 75–76, 124–126, 159, 575
- ASTM C 200, 344
- ASTM C 204, 300, 450–451
- ASTM C 207, 609

- ASTM C 215, 154, 156, 321–322
 ASTM C 219, 5, 462, 484
 ASTM C 227, 178, 216, 358–359, 367–369, 450, 452, 456, 459
 ASTM C 231, 51, 66, 69, 73, 75, 307, 486, 488, 514, 550
 ASTM C 232, 105, 108
 ASTM C 233, 489, 492
 ASTM C 235, 417
 ASTM C 236, 288, 523
 ASTM C 243, 108–109, 496
 ASTM C 260, 157, 159, 492, 594
 ASTM C 266, 450, 453–454
 ASTM C 267, 274
 ASTM C 270, 605, 609
 ASTM C 289, 178, 367–368
 ASTM C 290, 154–156
 ASTM C 291, 154, 156
 ASTM C 292, 154
 ASTM C 293, 71, 130–132
 ASTM C 295, 211, 341, 343–345, 348, 355, 361, 367–368, 372–373, 415–416, 418–419, 439
 ASTM C 298, 605–609
 ASTM C 309, 20, 478, 481–482, 594, 596, 602
 ASTM C 310, 154–155
 ASTM C 311, 20, 370, 450–451, 502–504, 507
 ASTM C 311–53T, 501
 ASTM C 325, 450
 ASTM C 330, 157, 398, 423, 522–524, 528–529, 593
 ASTM C 331, 398, 423, 524, 529
 ASTM C 332, 423, 523–524
 ASTM C 342, 452
 ASTM C 348, 457
 ASTM C 349, 457
 ASTM C 350, 501, 505
 ASTM C 350–54T, 501
 ASTM C 359, 454
 ASTM C 360, 58
 ASTM C 387, 604–605, 608–609
 ASTM C 387–56T, 604–605
 ASTM C 402, 501, 505
 ASTM C 402–57T, 501
 ASTM C 403, 79–80, 82, 84–86, 141
 ASTM C 403–57T, 77, 79
 ASTM C 403–90, 86
 ASTM C 418, 186, 188, 191, 389
 ASTM C 430, 450, 503
 ASTM C 441, 370, 459
 ASTM C 451, 450, 454
 ASTM C 452, 270, 272, 450, 452, 460
 ASTM C 457, 67–68, 247, 296, 300–307, 316, 344, 347, 351, 353, 361–362, 433, 486, 489
 ASTM C 469, 193–195, 529
 ASTM C 470, 72
 ASTM C 490, 154, 234
 ASTM C 493, 432
 ASTM C 494, 84–85, 157, 159, 169, 491–493, 495–497, 571, 597
 ASTM C 495, 528
 ASTM C 496, 130–131, 133, 528
 ASTM C 511, 74–75
 ASTM C 512, 72, 196–198
 ASTM C 513, 528
 ASTM C 518, 231
 ASTM C 535, 389–390, 415, 417
 ASTM C 563, 450, 458, 466
 ASTM C 566, 426
 ASTM C 567, 309–311, 527–528
 ASTM C 586, 373, 377, 379–380, 382–385
 ASTM C 595, 40, 236, 315, 449, 451, 456, 459, 467–468, 593, 609
 ASTM C 596, 225, 227, 452
 ASTM C 597, 325, 597
 ASTM C 617, 125–126
 ASTM C 618, 20, 235, 266, 270, 370, 456, 468, 501–505, 534, 562, 570, 594
 ASTM C 637, 398, 540, 543–544, 563–564, 593
 ASTM C 638, 540, 543–544, 564
 ASTM C 642, 253, 310–311, 590
 ASTM C 666, 154–159, 161, 216, 414, 530, 574, 582, 590
 ASTM C 670, 26–27, 144, 157, 188, 413, 437
 ASTM C 671, 154–155, 160–161, 414, 590
 ASTM C 672, 26, 154–155, 161, 276, 583, 590
 ASTM C 682, 154–155, 160–161, 414, 590
 ASTM C 684, 140, 142, 144–145, 150
 ASTM C 685, 511–513, 518–520, 596–597
 ASTM C 702, 373
 ASTM C 778, 457
 ASTM C 779, 186–188, 191, 389
 ASTM C 786, 450
 ASTM C 796, 492
 ASTM C 801, 134, 192
 ASTM C 802, 26
 ASTM C 803, 328, 331, 597
 ASTM C 805, 327, 597
 ASTM C 806, 225, 227, 450
 ASTM C 807, 450, 453–454
 ASTM C 823, 20, 211, 342, 373, 382, 550
 ASTM C 827, 452
 ASTM C 830, 432
 ASTM C 845, 224, 227, 449, 456
 ASTM C 851, 417
 ASTM C 856, 171, 211–212, 316, 342, 361, 373
 ASTM C 869, 492
 ASTM C 873, 124–126
 ASTM C 876, 170
 ASTM C 878, 225, 227
 ASTM C 881, 594, 600–601
 ASTM C 882, 600, 606
 ASTM C 883, 600
 ASTM C 884, 600, 602
 ASTM C 887, 606–608
 ASTM C 887–79a, 607
 ASTM C 900, 333, 597
 ASTM C 903, 591
 ASTM C 917, 26, 33, 35, 457, 589
 ASTM C 918, 140, 147–150, 335
 ASTM C 926, 610
 ASTM C 937, 540, 544, 563
 ASTM C 938, 540, 544, 563
 ASTM C 939, 540, 544, 565
 ASTM C 940, 108, 540, 544, 565
 ASTM C 941, 108, 110, 540, 544, 565
 ASTM C 942, 540, 544, 565
 ASTM C 943, 540, 544, 565
 ASTM C 944, 188–189, 389
 ASTM C 946, 606
 ASTM C 953, 540, 544, 565
 ASTM C 973, 591
 ASTM C 974, 492
 ASTM C 989, 370, 505–506, 570, 593
 ASTM C 995, 548, 550
 ASTM C 1012, 270, 272, 450, 452, 460
 ASTM C 1017, 157, 492–493
 ASTM C 1018, 548, 554–557, 560
 ASTM C 1038, 466, 450, 456
 ASTM C 1040, 310, 575
 ASTM C 1042, 599
 ASTM C 1059, 594, 599
 ASTM C 1064, 73, 75
 ASTM C 1073, 506
 ASTM C 1074, 148, 335
 ASTM C 1077, 518
 ASTM C 1076, 27
 ASTM C 1077, 39–40
 ASTM C 1078, 52, 112–113
 ASTM C 1079, 52, 112, 117
 ASTM C 1084, 272, 315–317
 ASTM C 1102, 492, 590, 594, 597
 ASTM C 1105, 373, 382–386
 ASTM C 1107, 606–609
 ASTM C 1116, 590, 594, 596–597
 ASTM C 1117, 85, 590, 597
 ASTM C 1137, 389, 393
 ASTM C 1138, 184, 189–191, 389, 391
 ASTM C 1140, 590, 594, 596–597
 ASTM C 1141, 491, 590, 594, 597
 ASTM C 1150, 333
 ASTM C 1151, 253, 482
 ASTM C 1170, 575
 ASTM C 1176, 575
 ASTM C 1202, 73, 168, 255, 583, 590
 ASTM C 1218, 171
 ASTM C 1222, 40
 ASTM C 1240, 507, 594
 ASTM D 75, 19, 343, 373
 ASTM D 98, 492
 ASTM D 448, 401
 ASTM D 854, 432
 ASTM D 2419, 417
 ASTM D 2434, 537
 ASTM D 2766, 232
 ASTM D 2936, 130–131
 ASTM D 3042, 389, 397
 ASTM D 3319, 389, 397–398
 ASTM D 3398, 405
 ASTM D 3663, 434
 ASTM D 3665, 19–20, 25
 ASTM D 3744, 389, 391–392
 ASTM D 4222, 433
 ASTM D 4404, 434
 ASTM D 4460, 27
 ASTM D 4525, 435
 ASTM D 4567, 434
 ASTM D 4580, 99
 ASTM D 4641, 433
 ASTM D 4780, 434
 ASTM D 4791, 405
 ASTM E 6, 192–193, 195
 ASTM E 11, 401
 ASTM E 105, 19
 ASTM E 119, 282, 291, 531
 ASTM E 122, 19, 25
 ASTM E 141, 19
 ASTM E 274, 389
 ASTM E 303, 397
 ASTM E 329, 39, 518
 ASTM E 548, 39
 ASTM E 660, 389, 397
 ASTM E 707, 389
 ASTM E 867, 397
 ASTM E 994, 39
 ASTM E 1085, 506
 ASTM E 1187, 39
 ASTM E 1224, 39
 ASTM E 1301, 39
 ASTM E 1322, 39
 ASTM E 1323, 39
 ASTM G 40, 182
 ASTM P 214, 368–369
 Attrition, tests, aggregates, 391–394

B

- Ball penetration test, 58–59
 Batching
 ready mixed concrete, 514–515
 roller-compacted concrete, 572
 shotcrete, 596

614 TESTS AND PROPERTIES OF CONCRETE

- Batching plant, ready mixed concrete, 515–516
- Beam
 reinforcement bond, 202–204
 stub-cantilever, 203
- Bearing strips, effect on splitting tensile strength, 133
- Belite, 464
- Binders, shotcrete, 593
- Bituminous materials, as contaminant, recycled concrete, 360
- Blank test, 117
- Bleeding, 88–111
 characteristics and setting time, 78
 consolidation and revibration effects, 107
 controlling, 107–108
 duration, 91–92
 effect on hardened concrete, 95–102
 blisters, 99, 101
 density, 96
 durability, 97–98
 mortar flaking, 98–99
 paste-aggregate bond, 96
 paste-steel bond, 96–97
 scaling, 97–98
 strength, 95–96
 surface delamination, 99–100
 surface appearance, 100, 102
 effects on plastic concrete
 placing and finishing, 95
 plastic shrinkage, 93–95
 postbleeding expansion, 93
 thixotropic mixtures, 94
 volume change, 92–93
 water/cement ratio, 94
 fundamentals, 88, 90–91
 impermeable subbase effect, 106
 increasing, 108
 ingredient effects, 101–105
 aggregate, 104
 cement, 101–103
 chemical admixtures, 104–106
 supplementary materials, 102–104
 water content and water/cement ratio, 101–102
 mathematical models, 110
 placement size and height effects, 105–106
 planes of weakness due to, 129
 reducing, 108
 remixing effect, 107
 significance, 88
 special applications, 110
 test methods, 108–110
 uniform seepage, 90
 water/cement ratio and, 90–92
 weather conditions effects, 106–107
 zones, 90–91
- Bleed water, 88–89
 removal, 108
- Blisters, bleeding effect, hardened concrete, 99–101
- BNQ 2560-070182, 393
- Bogue calculations, portland cement, 463
- Bond
 latex-modified portland cement, 582–583
 with reinforcing steel, 202–207
 strength
 cellular concrete, 536
 lightweight aggregate concrete, 531
- Bonding agents, 599–600
 shotcrete, 594
- Bond pullout pin test, setting time determination, 79–80
- Boron, fine-particle products, in radiation shielding, 545
- Break-off method, nondestructive tests, 333–334
- Brickwork, as contaminant, recycled concrete, 360
- BS 812, 393, 396
- BS 1881, 253, 550
- BS 5075, 79
- Bulk flow, 250–251
- Bulk modulus, temperature effect, 287
- C**
- Calcium chloride, as accelerating admixture, 494
- Calcium hydroxide, 270
 chemical resistance and, 264
 dehydration, 284
 leaching and deposition, 265
- Calcium nitrate, 169
- Calcium oxide, hydration, expansion due to, 224, 226
- Calcium sulfoaluminate, 267
- Calcium sulfate, reaction, 267–268
- Calorimeter, 235
- Capacitancy methods, water content analysis, 118
- Capillary absorption tests, 253
- Carbonate, addition to hydraulic cements, 471
- Carbonate aggregates, fire resistance, 285
- Carbonate rock (*see also* Alkali-carbonate rock reactivity)
 chemical composition and alkali-carbonate rock reactivity, 384–385
 expansive, composition, 377
 petrographic examination, 384
 reactive
 factors affecting expansion, 379–381
- Carbonation, 275
 depth of, 252
 portland-cement paste, 173
 shrinkage, 220–222
- Casting direction, effect on setting time, 129
- Cast-in-place concrete shielding, 543–544
- Cathodic protection, corrosion, 171
- Cellular concrete, 533–539
 applications, 534–535
 classification, 533–534
 construction and application techniques, 535, 538–539
 density, 534
 mixture proportioning, 538
 physical properties, 536–538
 quality control, 539
- Cement
 alkali level, alkali-silica reactivity and, 369–370
 brand, setting time and, 82
 carbonation behavior and, 221–222
 chemistry, accelerated curing and, 144–145
 effect on bleeding, 101–103
 fineness, heat of hydration and, 235
 latex-modified mixes, 580
 ready mixed concrete, 515
 roller-compacted concrete, 570
 type, setting time and, 82
 workability and, 53–54
- Cement and Concrete Laboratory, 40
- Cement content
 air-entraining admixture potential and, 487
 analysis, 112–117, 315–316
 absorption method, 113–114
 ASTM C 1078, 112–113
 ASTM C 1084 analysis, 317
 calculations and report, 317
 cement-type analysis, 317
 concrete consistency method, 117
 conductimetric method, 117
 constant neutralization method, 113
 Dunagan Bouyancy Method, 116
 flotation method, 115
 hydrometer analysis method, 116–117
 maleic acid analyses, 317
 sampling, 316–317
 nuclear cement gage, 116
 rapid analysis machine, 114–115
 thermal neutron activation, 116
 Willis and Hime Separation Method, 115–116
 dispersing agents, cellular concrete, 534
 fresh concrete, 52–53
 setting time and, 83, 86
- Cement gel, 7–8
- Cementing materials (*see also* Packaged, dry, cementitious mixtures)
 air-entraining admixtures, 487
 preplaced aggregate concrete, 562–563
 roller-compacted concrete, 569–570
- Cement paste
 composition
 environmental influences, 215–216
 high temperature properties and, 284–285
 creep, 242
 drying shrinkage and, 222–223
 fresh
 rheology, 9
 structure, 6–7
 structure, 12
 thermal conductivity, 230–231
- Central mixing, ready mixed concrete, 516–517
- Centrifuge test, 51
- Ceramic tile, thinsets and grouts, latex-modified, 586
- Chemical admixtures, 487, 491–497
 accelerating, 494
 applications, 494–495
 effect on bleeding, 104–106
 freeze-protection admixture, 497
 high-range water-reducing, 493–494
 pumping aids, 496–497
 sampling, 19–20
 set-retarding and water-reducing, 492–493
 specifications, 495–496
 standards, 491–492
 workability and, 54–55
- Chemical analysis, cement content, 315–316
- Chemical contamination, recycled concrete, 360
- Chemical degradation, moisture and, 173
- Chemical reaction, lightweight aggregate concrete, 530–531
- Chemical resistance (*see also* Corrosion, reinforcing steel; Sulfate resistance), 263–276
 acid attack, 272–274
 attack by other chemicals, 275–276
 calcium hydroxide and, 264
 carbonation, 275
 scaling, efflorescence, and leaching, 264–266
 seawater and brines, 274–275
 types of mechanisms, 263
 weathering processes, 264
- Chert, 415, 417
- Chloride
 induced corrosion, 164–167, 171
 in seawater, 274
 surface concentration, 255
- Clay
 expanded, petrographic examination, 357
 lumps, 415–416
- Clinker, impurities, 464
- Coal, 416
- Coatings, 602–603
 aggregate, 407–408, 418–419

- artificially generated, 418
 decorative, latex-modified, 586
 definition, 411-412
 effect on concrete, 418-419
 latex, 603
 naturally occurring, 418
 skid-resistant, latex-modified, 586
 synthetic-resin, 602-603
 water-resistant basement, latex-modified, 586
- Coefficient of thermal expansion, 439-440
- Cohesion, air content and, 297
- Compactibility, monitoring, roller-compacted concrete, 574-575
- Compacting factor test, 59-60
- Compaction, roller-compacted concrete, 573
- Compressibility, changes and setting time, 78-79
- Compressive strength, 10
 abrasion resistance and, 183-184
 aspect ratio, 128
 cellular concrete, 536
 diameter-to-aggregate ratio and, 128
 hardened grout, 565
 length of broken beam ends and, 128
 loading direction versus casting direction and, 129
 loading rate and, 130
 lightweight aggregate concrete, 527-528
 ready mixed concrete, 519-520
 recycled concrete, 359
 specimens
 end conditions and, 126-127
 geometry and, 130
 moisture condition and temperature, 129
 size and, 127-128
 temperature effect, 286-287, 290
 testing, 125-126, 130
 testing machine properties and, 129-130
 uniformity measurement, 53
- Compressive stresses, modulus of elasticity, 193-194
- Compressive toughness factor, 555
- Compressometer, 193-194
- Concrete
 definition, 5
 types, abrasion resistance and, 184
- Concrete consistency method
 cement content analysis, 117
 water content analysis, 118
- Concrete cores, corrosion, 171
- Concrete-making materials, 31-37
 definitions, 5
 properties affecting concrete performance, 31-33
 uniformity and, 31-33, 35-37
- Concrete Materials Engineering Council, 40
- Concrete prism expansion test, 382-383
- Concrete products, prepackaged, 609-610
- Conductimetric method, cement content analysis, 117
- Consistency, 11-12
 air content and, 487
 concrete consistency method, 117-118
 hydraulic cements, 451-452
 measurement, setting time determination, 77-78
 roller-compacted concrete, 571, 574-575
 workability and, 54
- Consolidation
 degree of, unit weight, 309
 effect on bleeding, 107
 fresh fiber-reinforced concrete, 548
- Constant neutralization method, cement content analysis, 113
- Contaminants
 detection, 343
 recycled concrete, 360-361
- Continuous mixing, ready mixed concrete, 518
- Copper and copper alloys, corrosion, 176-177
- Core and pullout test, 332-333
- Corrosion, 164-171, 173-174
 aluminum, 174-176
 anti-corrosion agent, 169
 asbestos, 180
 assessing severity of, 170-171
 cathodic protection, 171
 chloride-induced, 164-167
 chloride ion effect, 167-168
 chloride samples, 171
 concrete cores, 171
 copper and copper alloys, 176-177
 damage caused by, 166-167
 half-cell potential surveys, 170
 lead, 176
 mechanisms, 164-166
 precautionary steps against, 168-169
 prestressed concrete, 169-170
 products, 167
 repairs to deteriorated structures, 171
 steel-fiber-reinforced concrete, 179-180
 zinc, 169, 177
- Cracking
 alkali-carbonate rock reactivity, 374-375
 hardened fiber-reinforced concrete, 558-560
 high temperatures and, 291-292
 reinforcing steel bond effects, 207
 research, 44-45
- Cracking resistance, hardened fiber-reinforced concrete, 558-560
- CRD-C 36, 232
 CRD-C 37, 232
 CRD-C 38, 235
 CRD-C 44, 231
 CRD-C 45, 231
 CRD-C 124, 232
 CRD-C 141, 394
 CRD-C 242, 232
 CRD-C 401, 476
- Creep, 9-10, 195-198
 cement paste, 242
 equations, 196-197
 gel water, 196
 at high temperature, 287-288
 lightweight aggregate concrete, 529
 measurement, 196
 mechanism, 243-244
 paste content effect, 198
 prediction equations, 198
 principle of superposition, 197-198
 rheological models, 197
 significance of, 198-199
 specifications and, 199-200
 specimen size effect, 198
- Crushed stone, petrographic examination, 352-354
- CSA A23.2-14A, 382
- Curing
 abrasion resistance and, 185
 accelerated, 140-147
 apparatus, 141-142
 cement chemistry effect, 144-145
 experimental program, 140-141
 high temperature and pressure method, 145-146
 prediction of later-age strength, 146-147
 results, 142-143
 significance of test procedures, 143-144
 test precision, 144
 atmospheric conditions effect, 479-480
- autogenous, 143
 carbonation behavior and, 221
 compounds, 481-482
 effect on
 concrete properties, 478-479
 permeability, 256-258
 future work, 482-483
 lightweight aggregate concrete, 526-527
 methods and materials for moisture retention, 480-481
 new developments, 482
 roller-compacted concrete, 574
 shotcrete, 596
 standard, 74
 test methods and specifications, 481-482
 test specimens
 in field, 74
 in laboratory, 75
 water, 476-477
- Cyclic loading, cellular concrete, 538
- D**
- Damping properties, 322
- Dams, roller-compacted concrete, 567-568
- Darcy's law, 431
- Darcy's permeability, 251
- Deflection
 reinforcing steel bond effects, 207
 formula, 194-195
- Deformation testing, cellular concrete, 538
- Degradation
 aggregates
 coarse, 390-391
 impact on specifications, 398
 wet, 391-394
 chemical, moisture and, 173
- Dehydration, calcium hydroxide, 284
- Deleterious substances, 415-418
 chert, 415, 417
 clay lumps, 415-416
 coal and lignite, 416
 definition, 411
 effect on concrete, 416
 friable particles, 415-416
 material finer than 75 μ m, 416-417
 organic impurities, 417-418
 soft particles, 417
 tests, 416-418
- Density
 bleeding effect, hardened concrete, 96
 cellular concrete, 534
 hydraulic cements, 451
 in-place, roller-compacted concrete, 575
 preplaced aggregate concrete, 565
 radiation shielding, 542-542
 structural lightweight aggregate concrete, 527-528
- Deposition, 264-266
- Development length
 lightweight aggregate concrete, 531
 properties influencing, bond with reinforcing steel, 207
- Diameter-to-aggregate ratio, effect on setting time, 128
- Diatomite, petrographic examination, 358-359
- Dilation methods, freezing and thawing, 159-161
- DIN 1048, 253-254
- Direct tension test, setting time, 131
- Distress
 development of, 284
 manifestations, alkali-carbonate rock reactivity, 374-375
- Dolomite, floating, 375, 377
- Double-punch test, 131, 133

616 TESTS AND PROPERTIES OF CONCRETE

- Dressing-wheel abrasion test machine, 187-188
- Drying
effects, 8-9
rate, 173-174
shrinkage, 222-224, 275
- Dry-mix delivery equipment, shotcrete, 592
- Dunagan Bouyancy Method, 50, 116, 118
- Durability
bleeding effect, hardened concrete, 97-98
effect of cement paste capillary porosity, 478-479
exposure to seawater and brines, 275
hardened fiber-reinforced concrete, 560
hydraulic cements, 458-460
intrinsic, improvement, 264
latex-modified portland cement, 582-583
lightweight aggregate concrete, 529-530
research needs, 44-45
roller-compacted concrete, 574
- Durability factor, 156-158, 436
- Dynamic loading, hardened fiber-reinforced concrete, 557-558
- E**
- Echo method, nondestructive tests, 325
- Economics, significance of, sampling, 17
- Efflorescence, 265
- Elasticity, 9-10
relative dynamic modulus, 156
- Elastic properties, 192-195
aggregates, 395
lightweight aggregate concrete, 528-529
modulus of elasticity, 193-195
Poisson's ratio, 193, 195
significance of, 198-199
specifications and, 199-200
- Electrical resistance
measurement, 77
water content analysis, 118-119
- Embedded metals and materials, 173-180
aluminum, 174-176
asbestos, 180
copper and copper alloys, 176-177
fibers, 179
glass, 178
glass fibers, 180
lead, 176
organic materials, 180
other metals, 178
plastics, 179
recycled concrete, 180
steel fibers, 179-180
wood, 178-179
zinc, 169, 177
- Engineered fills, cellular concrete, 535
- ENV 197, 226
- Environment
alkali-silica reactivity and, 367
effect on
bleeding, 106-107
cement paste composition, 215-216
curing, 479-480
volume change and, 219
- Epoxy
fusion-bonded, 169
coating, effects on bond of bars, 205-206
resin systems, 600-602
- Ettringite, 267-268, 224
- Evaluation, sampling, 26
- Evaporation retardant, spray-applied, 480
- Expansion
reactive carbonate rock, 379-381
mechanism, 381
thermal, 284-285, 289
- Expansive cement, volume change, 224-225, 227
- Expansive dedolomization reaction, 373-374
- Exterior insulation finish systems, latex-modified, 586
- F**
- Fatigue strength, 135-137
- Feldman and Sereda's model, porosity, 242-243
- Fiber
applications, 179
chopped, cellular concrete, 534
content, fresh fiber-reinforced concrete, 550-551
glass, 180
Fiber-reinforced concrete, 547-560
fresh, 548-551
future, 560
hardened, 551-560
cracking resistance, 558-560
durability, 560
dynamic loading, 557-558
fiber content and orientation, 551-552
static loading, 552-557
strengthening, 552-554
tests for strength and toughness, 554-557
toughening, 554
nature of, 547-548
- Fick's law, 249
- Field concrete, deteriorated, 215-216
- Finely divided material, workability and, 54
- Fineness
cement, setting time and, 82-83
fly ash, 503-504
hydraulic cements, 449-451
- Fineness modulus, aggregates, 401-402
- Finishing
abrasion resistance and, 184-185
bleeding effect, fresh concrete, 95
lightweight aggregate concrete, 526-527
- Fire
damage, investigation and repair, 292-293
endurance ratings, 283
protection requirements, 282
testing, 282-284
- Fire resistance
aggregate component effect, 285
effect of embedded steel and structural systems, 285-286
moisture effects, 292
- Flexural bond stresses, 206
- Flexural members, deflection, 198
- Flexural strength
factors affecting, 131-132
relationship to splitting tensile strength, 133
temperature effect, 287
testing, 130-131
- Flexural toughness factor, 555
- Flexure, modulus of elasticity, 194-195
- Floor fill, cellular concrete, 534-535
- Floor resurfacing, prepackaged, 610
- Flotation method, 115, 118
- Flow cone, workability measurement, 60-61
- Fluid penetration coefficient, 254
- Fly ash
alkali-silica reactivity, 370, 504
benefits, 501
carbonation behavior and, 221-222
cellular concrete, 534
cement paste thermal properties and, 284
chemical composition, 468
chemical requirements, 501-502
classification, 501-505
effect on bleeding, 102-103
heat of hydration, 235
physical requirements, 503-504
preplaced aggregate concrete, 562-563
quality assurance, 504-505
sulfate resistance, 270-271
supplementary optional requirements
chemical, 502-503
physical, 504
test requirements not in specifications, 504
- Freeze-protection admixture, 497
- Freeze-thaw, 153-162
carbonation behavior and, 221
damage
air voids and, 297-298
mechanism, 297
slow-freeze conditions, 298
dilation methods, 159-161
durability problems, 436
historical evolution, 154-155
lightweight aggregate concrete, 530
petrographic examination, 216
rapid tests, 156-159
research needs, 45
in salt solution, alkali-carbonate rock reactivity potential, 385
salt water use, 159
scaling resistance, 161
standardized test methods, 154
testing
concrete, 414-415
unconfined aggregates, 414
theoretical considerations, 155-156
- Freeze-thaw resistance
aggregates, 298
air content and, 297
air voids and, 298, 486
cellular concrete, 538
recycled concrete, 359
- Fresh concrete
air content measurement, 65-68
bleeding effects
placing and finishing, 95
plastic shrinkage, 93-95
postbleeding expansion, 93
thixotropic mixtures, 94
volume change, 92-93
water/cement ratio, 94
cement content (*see* Cement content, analysis)
determining air void characteristics, 488
entrained air
factors affecting amount and character, 486-488
function, 485-486
sampling, 20, 66
temperature measurement, 65-66
unit weight measurement, 65
water content analysis, 52, 117-119
- Friable particles, 415-416
tests for, 416
- Frictional properties, aggregates, 397-398
- Frost (*see* Freeze-thaw)
- G**
- Gas, permeability testing and standards, 252
- Gas diffusion, 252
- Glass
as contaminant, recycled concrete, 360
content, blast-furnace slag, 506
fibers, reactivity, 180
reactivity, 178
- Glycol ether derivatives, 221
- Goodman diagram, 136
- Grading, aggregates, 401-405, 422
definition, 401
lightweight, 525

- roller-compacted concrete, 570–571
 significance, 402
 specification, 405
 test method, 401–402
- Gravimetric method, unit weight of fresh concrete, 69
- Grout
 analysis, 317
 ceramic tile, latex-modified, 586
 fluid characteristics, preplaced aggregate concrete, 565
 fluidifier, preplaced aggregate concrete, 563
 mix proportions, preplaced aggregate concrete, 563–564
 mixtures, cellular concrete, 538
 surface monitoring, preplaced aggregate concrete, 564–565
- Gypsum, 267
- H**
- Half-cell potential surveys, corrosion, 170
- Hardened cement paste
 compressive strength, 10
 drying effects, 8–9
 elasticity and creep, 9–10
 microstructure, 241–242
 permeability, 10
 porosity, 240–241, 244–245
 properties, 13
 thermal expansion, 10
- Hardened concrete
 air content, 296–300
 bleeding effect, 95–102
 blisters, 99, 101
 density, 96
 durability, 97–98
 mortar flaking, 98–99
 paste-aggregate bond, 96
 paste-steel bond, 96–97
 scaling, 97–98
 strength, 95–96
 surface appearance, 100, 102
 surface delamination, 99–100
 determining air void characteristics, 489
 entrained air function, 485–486
 petrographic examination, 211–212
 aggregates, 347–348
 placed by preplaced aggregate method, 565
 porosity, 246
 sampling, 20
 specimens cut from existing structures, 125
 unit weight, determining, 310–311
- Hardening reactions, microstructure and, 7–8
- Hardness
 aggregates, 395–397
 mixing water, effect on air content, 476
- Heat flow, 236–237
- Heat generation, importance of, 236
- Heat of hydration, 234–236
 hydraulic cements, 455
 setting time and, 78
- High-range water-reducing admixtures, 169, 493–494
- High temperature and pressure method, accelerated curing, 145–146
- History, of field concrete, reconstruction, 215
- Hydration, 77
 cement paste permeability and, 245
 early reactions, 7
 effects on permeability, 256–257
 free CaO and MgO, expansion due to, 224
 heat of, 234–236
 portland cement, 464
- Hydraulic cements (*see also* Portland cement), 449–461
 activity index, 451
 air content, 458–459
 alkali-silica reactivity, 459
 alkali sulfates, 471
 blended, 467–468
 carbonate additions, 471
 chemical properties, 462–472
 composition test methods, 468–470
 consistency, 451–452
 definition, 5
 density, 451
 durability, 458–460
 fineness, 449–451
 heat of hydration, 455
 optical microscopy, 470
 performance versus prescription standards, 471–472
 physical properties test methods, 450
 quantitative phase analysis, 470–471
 quantitative X-ray diffraction, 470
 sampling, 20
 scanning electron microscopy, 470
 setting time, 452–455
 SO₃ content, 471
 optimum, 458
 strength, 456–458
 sulfate attack, 459
 trace elements, 471
 user's concerns, 471
 volume change, 455–456
- Hydraulic pressure theory, 155
- Hydrochloric acid, 273
- Hydrometer analysis method, cement content analysis, 116–117
- I**
- Image analysis techniques, air-void systems, 307
- Impermeable subbase, effect on bleeding, 106
- Impulse response method, nondestructive tests, 325
- Impurities, effect on mixing water, 474–475
- Industrial cinders, petrographic examination, 357
- Insoluble residue, limits in portland cement, 465
- Inspector, sampling as duty of, 17–18
- Insulation, winter concreting, 238
- Ionic diffusion, 254–255
- Irradiation, effects on radiation shielding, 543
- ISO Guide 49, 39
- ISO Guide 25, 39
- J**
- JSCE-SF4, 554–555, 557
- JSCE-SF5, 554–555
- JSCE-SF6, 554–555
- JSCE-SF7, 551
- K**
- Kelly ball test, 58–59
- Kozeny equation, 431
- K-slump tester, 55–57
- L**
- Langlier Index, 265
- Lapped splice, reinforcing steel bond, 205
- Latex (*see also* Portland cement, latex-modified), 577
 carbonation resistance, 221
 cellular concrete, 534
 coatings, 603
 formulation, 579–580
 modification mechanism, 578–579
- permeability and, 169
 prepackaged patching products, 610
 shotcrete, 594
 types, 577–578
- Leaching, 264–266, 273
- Lead, corrosion, 176
- Lift surface, treatment, roller-compacted concrete, 573
- Lightweight aggregate concrete, 522, 526–531
 abrasion resistance, 531
 bond strength and development length, 531
 cellular, 533–534
 chemical reaction, 530–531
 classification, 522
 compressive strength, 527–528
 creep, 529
 density, 527–528
 durability, 529–530
 elastic properties, 528–529
 insulating-grade, 523
 mixing, placing, finishing, and curing, 526–527
 popouts, 531
 proportioning, 526
 shrinkage, 529
 structural-grade, 522–523
 structural/insulating, 523
 tensile strength, 528
- Lightweight aggregates, 522–526
 absorption characteristics, 525
 bulk unit weight, 524
 classification, 522
 grading, 525
 insulating-grade, 523
 internal structure, 523–524
 modulus of elasticity, 525–526
 petrographic examination, 357–359
 shape and texture, 523–524
 specific gravity, 524
 structural-grade, 522–523
 total porosity, 524–525
- Lignite, 416
- Lignosulfonate water-reducing retarders, 493
- Lime, in fly ash, 503
- Lime-saturated water, 265
- Linear traverse method, air-void systems, 303–304
- Linseed oil, 603
- Liquid displacement techniques, porosity, 246–247
- Lithium salts, alkali-silica reactivity and, 371
- Loading
 center-point versus third-point, effect on flexural strength, 132
 direction, effect on setting time, 129
 rate, effect on
 flexural strength, 132
 setting time, 130
 splitting tensile strength, 133
- Lorman equation, 197
- Los Angeles abrasion, 390–391
- Loss on ignition
 fly ash, 502
 portland cement, 465
- M**
- Magnesium, sulfate reaction, 268–269
- Magnesium oxide
 in fly ash, 503
 hydration, expansion due to, 224, 226
 limits in portland cement, 465
- Magnetite, 167
- Maleic acid, cement content determination, 317

618 TESTS AND PROPERTIES OF CONCRETE

- Mass concrete, roller-compacted concrete, transporting, 572
- Mass transfer, 247–252
adsorption, 247–248
ionic diffusion, 254–255
- Mathematical models, bleeding, 110
- Maturity functions, 334–335
- Maturity index, 148
- Maturity method, 147–150
application, 148–149
interpretation of results, 144–150
nondestructive tests, 334–335
precautions, 150
strength-maturity relationship, 148
- Mechanical properties
hardened fiber-reinforced concrete, 552–557
lightweight aggregate concrete, 293
moisture content effect, 290–291
permeability and porosity and, 255–259
temperature effects, 286
very high strength concrete, 293
- Mercury intrusion porosimetry, 247
- Metallic contaminants, recycled concrete, 360
- Microbars, autoclaved, 385
- Micro-Deval test, 393
- Microsilica, chemical composition, 468
- Microstructure, hardening reactions and, 7–8
- Microwave-absorption method, water content analysis, 119
- Microwave oven, concrete separation, 118
- Mineral admixtures, 500–507
blast-furnace slag, 505–506
definitions, 500
pozzolans, 500–505
sampling, 20
silica fume, 507
- Minerals, in radiation shielding, 542
- Mixing
action and air entrainment, 487–488
equipment, shotcrete, 593
lightweight aggregate concrete, 526–527
proportioning (*see* Proportioning)
ready mixed concrete, 516–517
roller-compacted concrete, 572
shotcrete, 596
- Mixing water, 473–476
algae effects, 475–476
hardness and air content, 476
impurity effect, 474–475
ready mixed concrete, 515
seawater, 475
- Modeling, fire resistance, 283
- Modified point count method, air-void systems, 304
- Modulus of elasticity
aggregates, 395
cellular concrete, 536–537
in compression, 193–194
dynamic, 320–321
calculation, 321–322
factors affecting, 322
from pulse velocity, 324
in flexure, 194–195
lightweight aggregates, 525–526
in shear, 195
specifications and, 199
structural design and, 198
temperature effect, 287
in tension, 194
- Modulus of rigidity, dynamic, 322
- Moisture
availability, alkali-silica reactivity and, 367
chemical degradation and, 173
fire resistance and, 283, 292
flexural strength and, 132
mechanical and thermal performance and, 290–291
retention, curing methods and materials, 480–481
surface, aggregates, 425–426
test specimen, effect on setting time, 129
Moisture clog spalling, 292
- Mortar
analysis, 317
flaking, bleeding effect, hardened concrete, 98–99
latex-modified
mixes, 580
portland cement, 583, 586
prepackaged products, 610
- Mortar bar method, alkali-silica reactivity, 367–368
- MTO LS-614, 393
- MTC LS-615, 385
- Munich model, porosity, 243–244
- N**
- National Voluntary Laboratory Accreditation Program, 40–41
- Neat-cement cellular concrete, 533
- Neutron-scattering methods, water content analysis, 119
- Nondestructive tests, 320–336
break-off method, 333–334
combined methods, 335–336
maturity method, 334–335
pin penetration test, 331
probe penetration test, 327–331
pulloff tests, 335
pullout test, 332–333
pulse velocity method, 323–325
rebound method, 325–327
resonant frequency methods, 320–323
stress wave propagation methods, 325
- Nuclear cement gage, cement content analysis, 116
- Nuclear models, 541
- Nuclear shielding (*see* Radiation shielding)
- Nurse-Saul maturity function, 334
- O**
- Optical microscopy, hydraulic cements, 470
- Organic impurities, tests for, 417–418
- Organic materials, 180
adhesives, patching, and overlaying materials, 600–602
bonding and patching materials, 599–600
coatings, 602–603
sealers, 603
- Otto Graf viscosimeter, 61–62
- Overlaying materials, 600–602
- P**
- Packaged, dry, cementitious mixtures, 604–610
applications, 608
availability, 608
future needs, 609–610
hazardous considerations, 604–605
history, 604
materials, 609
packaging, 609
quality control, 608–609
specifications, 605–607, 609
use, 607–608
- Paint, latex-modified cement maintenance, 586
- Particles, strength, concrete aggregates, 11
- Paste-aggregate bond
bleeding effect, hardened concrete, 96
permeability, 246
- Paste-steel bond, bleeding effect, hardened concrete, 96–97
- Patching materials, 599–602
latex-modified, prepackaged, 610
- Pavements
polymer-modified concrete, 586–587
roller-compacted concrete, 568–569
placement, 573–574
transporting, 572–573
wear, 397–398
- Penetration resistance method, setting time determination, 78–79
- Perlite, petrographic examination, 358
- Permeability, 10, 435–436
admixtures and, 256
aggregate, 246
cellular concrete, 537
cement paste, hydration and, 245
concrete aggregates, 11
correlation with strength, 259
corrosion and, 168–169
effect of curing and conditioning, 256–258
factor in seawater attack, 274
hydration and, 256–257
latex-modified portland cement, 583–585
paste-aggregate interface, 246
pore structure and, 240–241
porosity and, 255–259
testing and standards, 252–255
gas, 252
ionic diffusion, 254–255
water, 253–254
unit weight and, 309
water/cement ratio and, hardened cement paste, 245, 255–257
- Permeability coefficient, intrinsic, 252
- Petrographic examination, 210–217
age of concrete, 214
aggregates, 341–362
alkali reactivity, 348
contamination detection, 343
correlation of samples with aggregates previously tested or used, 342
determining processing effects, 343
establishing properties and probable performance, 342
examination in field, 343, 348–349
examination in laboratory, 343–345, 349–352
hardened concrete, 347–348
lightweight, 357–359
natural, 348–352
observations included, 345–346
particle condition, 346–347
potentially reactive, identifying, 368
preliminary determination of quality, 341–342
proportions of coarse and fine aggregates, 347–348
purpose, 341–343
samples, 343
selecting and interpreting tests, 342
- approach, 213
blast-furnace slag, 354–357
cement content, 316
communications, 211
comparisons, 214
composition and, 215
crushed stone, 352–354
dolomitic carbonate rocks, 384
fabric and composition, 213–214
freezing and thawing, 216
interpretation of observations, 214

- methods, 211–212
 normal and unusual concrete, 215
 purpose, 213
 reconstruction of history of field concrete, 215
 recycled concrete, 359–362
 for soundness, 415
 sources of concrete, 214–215
- Petrography**, 210–211
- Pin penetration test**, nondestructive tests, 331
- Placeability, workability, measurement**, 57
- Placement**
 bleeding effect, fresh concrete, 95
 lightweight aggregate concrete, 526–527
 at low temperature, 238
 roller-compacted concrete, 573–574
 size and height, effect on bleeding, 105–106
- Plastic, resistance to strong alkalis**, 179
- Plasticity, aggregate structure and**, 12
- Plastic properties**
 latex-modified portland cement, 581
 shrinkage, fresh concrete, 93–95
- Poisson's ratio**, 193, 195
 aggregates, 395
 calculation, 321–322
 temperature effect, 287
- Polishing**, 396
- Polymers**, 180
 abrasion resistance and, 184
 carbonation behavior and, 221
 shotcrete, 594
- Popouts, lightweight aggregate concrete**, 531
- Pore size**
 measurement, 433–434
 parameters, 430–431
- Pore space, quantitative assessments**, 429
- Pore structure, permeability and**, 240–241
- Pore system, coarse aggregates**, 429–437
 concepts and definitions, 429–431
 measurement of other parameters, 435
 pore size, 430–431, 433–434
 pore volume, 430, 432–433
 significance, 435–437
- Pore volume**
 measurement, 432–433
 parameters, 430
- Porosity**, 240–247, 433
 aggregates, 246
 bulk flow, 250–251
 concrete aggregates, 11
 Feldman and Sereda's model, 242–243
 hardened cement paste, 244–245
 microstructure, 241–242
 in hardened concrete, 246
 lightweight aggregates, 524–525
 measurement methods, 246–247
 mixing-and-placing, 246
 Munich model, 243–244
 paste-aggregate interface, 246
 permeability and, 255–259
 Powers' model, 241–242
 surface diffusion, 248–249
 vapor diffusion, 249–250
 water/cement ratio, 297
- Portland cement** (*see also* Latex), 462–465
 ASTM C 150 chemical requirements, 465–467
 autogenous shrinkage, 219–220
 Bogue calculations, 463
 chemical composition, 462–463
 definition, 5
 hydration reactions, 464
 impurities in clinker phases, 464
 insoluble residue limits, 465
 latex-modified, 577–587
 air void system, 581–582
 applications, 583, 586–587
 bond, 582–583
 durability, 582–583, 583
 equipment, 587
 latex types, 577–578
 limitations, 587
 mechanism, 578–579
 plastic properties, 581
 properties, 580–583
 specifications, 587
 strain capacity, 583
 loss on ignition, 465
 magnesium oxide limits, 465
 major phases and cement properties, 464–465
 microstructure, 241–242
 optional chemical requirements, 467
- paste**
 carbonation, 173
 microstructure, 7–8
 phase composition, 463
 slag activity test, 506
 SO₃, 466
 sulfate resistance, 269–270
- Type I, ASTM C 150 chemical requirements**, 466
- Type II, ASTM C 150 chemical requirements**, 466–467
- Type III, ASTM C 150 chemical requirements**, 467
- Type IV, ASTM C 150 chemical requirements**, 467
- Type V, ASTM C 150 chemical requirements**, 467
- volume change, tests, 226, 226–227
- Postbleeding expansion, fresh concrete**, 93
- Powers' model**, 241–242
- Powers' spacing factor**, 301–302
- Pozzolans** (*see also* Fly ash), 500–505
 alkali-silica reactivity and, 370
 chemical composition, 468
 effect on bleeding, 104
 heat of hydration, 235
 history and use, 500–501
 natural, 505
 ready mixed concrete, 515
 roller-compacted concrete, 570
 shotcrete, 594
 sulfate resistance, 270–271
- Precast cellular concrete elements**, 535
- Precast concrete shield blocks**, 543–544
- Precision, ASTM C 403**, 82
- Preplaced aggregate concrete**, 562–565
 aggregates, 563
 cementing materials, 562–563
 grout fluidifier, 563
 grout mix proportions, 563–564
 radiation shielding, 544
 specifications, 564–565
- Pressure air measurement**, 66–68
- Prestress, loss of**, 198
- Prestressed concrete**
 corrosion, 169–170
 fire tests, 292
 reinforcing steel bond, 206–207
- Principle of superposition, creep**, 197–198
- Probability sampling**, 21
- Probe penetration test**
 advantages and disadvantages, 331
 nondestructive tests, 327–331
- Production, uniform concrete**, 50–53
- Proportioning**, 11–12
 abrasion resistance and, 183–184
 cellular concrete, 538
 grout, preplaced aggregate concrete, 563–564
 lightweight aggregate concrete, 526
 roller-compacted concrete, 571–572
 shotcrete, 595–596
 workability and, 55
- Pulloff tests**, 335
- Pullout test**, 332–333
- Pulse velocity method**, 323–325
- Pumice, petrographic examination**, 357–358
- Pumping aids**, 496–497
- Q**
- Quality assurance**
 fly ash, 504–505
 roller-compacted concrete, 574–575
 shotcrete, 596
- Quality control**
 cellular concrete, 539
 packaged, dry, cementitious mixtures, 608–609
 roller-compacted concrete, 574–575
 sampling and, 18
 slag, 506
- Quantitative phase analysis, hydraulic cements**, 470–471
- Quantitative X-ray diffraction, hydraulic cements**, 470
- Quick Chemical Test**, 368
- R**
- Radiation**, 540–541
 exposure effects on concrete, 544–545
- Radiation shielding**, 293, 540–545
 absorption and scattering interaction, 543
 concrete, 542–543
 construction verification, 545
 fine-particle boron products, 545
 optimization, 545
 physical and biological explanation, 541
 research, 544–545
 size and economics, 543
 standards, 543–544
 Subcommittee C09.41, 540
 terminology, 541–542
 unit weight and, 310
- Radioactivity, recycled concrete**, 360
- Rapid analysis machine, cement content analysis**, 114–115
- Rapid mortar-bar expansion test, alkali-silica reactivity**, 368–369
- Ready mixed concrete**, 511–520
 admixtures, 515
 aggregates, 515
 basis of purchase, 512
 batching and measuring materials, 514–515
 batching plant, 515–516
 cement and pozzolans, 515
 compressive strength, 519–520
 history, 511
 materials, 513–514
 mixing, 516–517
 mixing water, 515
 ordering information, 512–513
 recorders, 516
 sampling and testing, 518–520
 slump and air content, 514
 specifications, 511–512
 volume in-place, 512
 volumetric batching and continuous mixing, 518
 water addition control, 517–518
 water/cement ratio, 513
 water quality, 514
 yield, 512
- Rebound hammer test**, 325–327, 392

620 TESTS AND PROPERTIES OF CONCRETE

- Recycled concrete, 180
admixtures, 359
compressive strength, 359
field examination, 361
freeze-thaw resistance, 359
petrographic examination, 359-362
unsound, 359-360
- Refractory concrete, thermal properties, 293-294
- Refractory shotcrete, 591
- Regression lines, 24-25
- Reinforcing, shotcrete, 594
- Reinforcing steel (*see also* Corrosion)
bond with, 202-207
epoxy coating effects, 205-206
influence in control of cracking and deflections, 207
lapped splices, 205
prestressed concrete, 206-207
properties influencing development length, 204-205
splitting failures, 205
tests, 202-204
coating, 169
fire resistance and, 285-286
- Relaxation length, 542
- Remixing, effect on bleeding, 107
- Repairs, deteriorated structures, 171
- Research needs
basic research, 42-43
reappraisal of past research, 43
training of researchers, 43
use of standard tests, 44-45
- Resonant frequency methods, nondestructive tests, 320-323
- Retarding admixtures (*see* Set-retarding admixtures)
- Revibration, effect on bleeding, 107
- Revolving-disk abrasion test machine, 186-187
- Rheological models, creep, 197
- Rheology, fresh cement paste, 9
- Rice husk ash, effect on bleeding, 104
- Ring anode effect, 171
- Rock cylinder expansion test, 383-384
- Rock prisms, 385
- Roller-compacted concrete, 567-575
admixtures, 571
advantages, 569
aggregates, 570-571
applications, 568-569
batching and mixing, 572
cement, 570
cementitious materials, 569-570
curing, 574
definition, 567
hardened, properties, 574
history, 567-568
mixture proportioning, 571-572
placement, 573-574
pozzolans, 570
quality control and assurance, 574-575
transporting, 572-573
- Roof decks, cellular concrete, 535
- Rotating-cutter drill press, 188-189
- Rust, 167
- S
- Salt attack, 276
- Salt scaling, 276
- Samples (*see also* Test specimens)
aggregates for petrographic examination, 343
compositing, 18
definition, 15
for field, 73
obtaining, 16-17
preparation, cement analysis, 316-317
protection, 18
selection, cement analysis, 316
variability, recognition of, 21
- Sampling, 15-22
admixtures
chemical, 19-20
mineral, 20
aggregates, 19
for alkali-carbonate rock reactivity, 385
ASTM standards, 16, 21
definition, 15-16
as duty of inspector, 17-18
economic significance, 17
evaluation, 26
fresh concrete, 20, 66
fresh fiber-reinforced concrete, 548
hardened concrete, 20
hydraulic cement, 20
plan, 16
probability, 21
procedural sources of uncertainty and variability, 306
quality control and, 18
ready mixed concrete, 519
statistics, 24-26
stratified random, 25-26
test specimens (*see* Test specimens)
trained personnel, 21
- Sand, workability and, 54
- Sandblasting, abrasion testing, 186
- Sanded cellular concrete, 533
- Saturated flow, water, 254
- Saturation, degree of, freezing and thawing tests, 159
- Scaling, 156, 265
bleeding effect, hardened concrete, 97-98
resistance, 161
salt, 276
- Scanning electron microscopy, hydraulic cements, 470
- Scattering cross section, 542-543
- Schmidt rebound hammer, 325-327
- Scoria, petrographic examination, 357-358
- Sealers, 169, 171, 603
abrasion resistance and, 185
for curing, 481
- Seawater, 274-275
as mixing water, 475
- Selective dissolution, hydraulic cements, 469
- Set-accelerating admixtures, setting time and, 84
- Set-retarding admixtures, 492-493
applications, 495
roller-compacted concrete, 571
setting time and, 84
- Setting shrinkage, fresh concrete, 93-95
- Setting time, 77-87
aspect ratio and, 128
bleeding characteristics and, 78
bond pullout pin test, 79-80
casting direction effect, 129
cement brand and type, 82
cement content, 83, 86
compressibility changes and, 78-79
compressive, 125-126
test result significance, 130
concrete mixtures and, 81-82
concrete under combined states of stress, 134-135
consistency and, 77-78
diameter-to-aggregate ratio effect, 128
direct tension test, 131
double-punch test, 131, 133
fatigue strength, 135-137
fineness of cement and, 82-83
flexural, 130-132
future considerations, 86-87
heat of hydration, 78
history, 77-78
hydraulic cements, 452-455
loading direction effect, 129
loading rate effect, 130
moisture effect, 129
obtaining test specimens, 124-125
penetration resistance method, 78-79
preplaced aggregate concrete, 565
purposes, 123
set-retarding and-accelerating admixtures, 84
shear and torsional strength, 134
sound velocity and frequency, 78
splitting tensile strength, 131-133
strength relationships, 78, 133
temperature and, 83-84, 129
tensile strength, 130-131, 133
tests
acceptance specifications, 84-85
field concreting, 85
test specimens, 124-125
treatment of data, 80-81
volume change and, 78
water/cement ratio, 83, 85
- Sewer lines, acid attack, 273
- Shale, expanded, petrographic examination, 357
- Shape, 405-406
aggregates, 421-422
lightweight aggregates, 523-524
- Shear, modulus of elasticity, 195
- Shear strength, 134, 536
- Shotcrete, 589-597
ACI recommended practices, 590
admixtures, 594
aggregates, 593
air compressors, 592-593
ancillary equipment, 593
applications, 592
ASTM standards, 590-591
batching and mixing, 596
binders, 593
bonding agents, 594
curing, 596
definition, 589
dry-mix delivery equipment, 592
history, 590, 591-592
latex-modified, 586
mixing equipment, 593
mixture proportioning, 595-596
polymers, 594
pozzolans, 594
prepackaged, 610
properties, 590
quality assurance, 596
refractory, 591
reinforcing, 594
terminology, 589-590
testing, 597
water, 593-594
wet-mix delivery equipment, 592
- Shrinkage
autogenous, portland cement, 219-220
carbonation, 220-222
drying, 222-224, 275
lightweight aggregate concrete, 529
mechanism, 243-244
plastic, 93-95
- Shrink mixing, ready mixed concrete, 517
- Silanes, 169, 171, 603
- Silica, acid-soluble, 316
- Silica fume, 169, 507

- abrasion resistance and, 184
alkali-silica reactivity and, 371
cement paste thermal properties and, 284
chemical requirements, 507
drying shrinkage and, 223-224
effect on bleeding, 104
history and use, 507
physical requirements, 507
sulfate resistance, 270-271
- Siliceous aggregates, fire resistance, 285
- Slag, blast-furnace, 505-506
activity test, portland cement, 506
advantages, 505
blast-furnace, 354-355
alkali-silica reactivity, 370-371
chemical composition, 468
carbonation behavior and, 222
cement paste thermal properties and, 284
classification, 505-506
effect on bleeding, 103
expanded, petrographic examination, 357
glass content, 506
history and use, 505
petrographic examination, 354-357
sulfate resistance, 270-271
- Slate, expanded, petrographic examination, 357
- Slump, ready mixed concrete, 514
- Slump test, 52, 55
- Slurry mixtures, cellular concrete, 538
- SO₃
in blast-furnace slag, 506
in fly ash, 502
hydraulic cement content, 471
limit in portland cement, 466
optimum
hydraulic cements, 458
portland cement, 466
- Sodium sulfate, reaction, 268
- Soft particles, tests for, 417
- Soils compaction, roller-compacted concrete, 571-572
- Sonoscope, 323-324
- Sound, velocity and frequency measurements, setting time, 78
- Soundness, 412-415
absorption tests, 414
definition, 411
fly ash, 503
freeze-thaw testing
concrete, 414-415
unconfined aggregate, 414
petrographic examination, 415
recycled concrete, 359-360
sulfate soundness test, 412-414
- Spalling, high temperatures and, 291-292
- Specific gravity, aggregates, 11, 424-425
lightweight, 524
- Specific heat, 231-232
aggregates, 442
determining, 288-289
- Specific surface, air-void system, 300-301
- Splitting tensile strength
factors affecting, 132-133
relationship to flexural strength, 133
setting time, 131
- Standardization
break-off test, 333-334
maturity method, 335
penetration resistance techniques, 331
pullout tests, 333
pulse velocity method, 324-325
rebound test method, 327
resonant frequency methods, 322
- Standards
aggregates, 389
alkali-carbonate rock reactivity, 372-373
chemical admixtures, 491-492
hydraulic cement, 471-472
permeability, 252-255
radiation shielding, 543-544
sampling, 16, 21
shotcrete, 590-591
uniformity, guidelines for future, 35-37
- Static loading, hardened fiber-reinforced concrete, 552-557
Statistics
parameters, 23-24
precision and bias statements, 26-27
regression lines, 24-25
testing, 26
- Steel-fiber-reinforced concrete, corrosion, 179-180
- Steel fibers, in fiber-reinforced concrete, 551
- Stiffness, determination and setting time, 78
- Strain capacity, latex-modified portland cement, 583, 585
- Strength (*see also* Compressive strength; Tensile strength)
aggregates, 388-389, 394-395
bleeding effect, hardened concrete, 95-96
cement paste capillary porosity and, 478-479
correlation with permeability, 259
determination and setting time, 78
effects of algae in mixing water, 475-476
factors affecting, 71
fracture mechanics, 44
hydraulic cements, 456-458
nature of, 123-124
predicting at later ages, 140-151
accelerated curing methods, 140-147
maturity method, 147-150
rebound hammer test, 326-327
reduction, air content and, 297
relationships, 133
testing, 123-137
thermal cycling effect, 290
- Strengthening, hardened fiber-reinforced concrete, 552-554
- Strength-maturity relationship, 148
- Stress
calculations, rheological behavior and, 198-199
combined states, 134-135
levels and fire resistance, 283
- Stress-strain curve, 192-193
- Stress wave propagation methods, nondestructive tests, 325
- Structural design, elastic properties, 198
- Structure, cement paste, 12
- Stucco products, prepackaged, 610
- Sulfate attack, 266-271
calcium sulfate, 267-268
control, 269-271
factors governing reactions, 266
hydraulic cements, 459
magnesium sulfate, 268-269
sodium sulfate, 268
- Sulfate resistance, 266-272
sulfate attack, 266-269
control of, 269-271
tests, 271-272
- Sulfate soundness test, 412-414
- Sulfuric acid, 273
- Supplementary cementing materials, effect on bleeding, 102-104
- Surface
appearance, bleeding effect, hardened concrete, 100, 102
delamination, bleeding effect, hardened concrete, 99-100
diffusion, 248-249
hardness
pin penetration test, 331
probe penetration test, 327-331
rebound method, 325-327
treatment, abrasion resistance and, 185
Sweating (*see* Bleeding)
- Swelling, mechanism, 243-244
- T**
- Temperature
air-entraining admixtures, 488
effect on
compressive strength, 286-287, 290
creep, 287-288
flexural strength, 132, 287
mechanical properties, 286
modulus of elasticity, Poisson's ratio and bulk modulus, 287
radiation shielding, 543
high
coupled with blast, 294
spalling and cracking, 291-292
measurement, fresh concrete, 65-66
setting time and, 83-84, 129
at time of grout injection, preplaced aggregate concrete, 564
- Tensile strength
cellular concrete, 536
lightweight aggregate concrete, 528
splitting, setting time, 131
test
procedures, 130-131
result significance, 133
- Tension, modulus of elasticity, 194
- Testing (*see also* specific materials)
concerns, 38
statistics, 26
trends in promoting quality, 38-40
- Testing laboratories
evaluating authorities, 40-41
quality promotion trends, 38-40
technician competency, 41
testing concerns, 38
- Testing personnel, test specimens, 71-72
- Test specimens (*see also* Samples), 71-78
air-void systems, 302
applications, 71-72
beam-end, 204
compressive strength
aspect ratio, 128
diameter-to-aggregate ratio, 128
end condition effect, 126-127
geometry effect, 130
length of broken beam ends effect, 128
loading rate effect, 130
loading versus casting direction, 129
moisture condition and temperature effect, 129
size effect, 127-128
consolidation, 75
cut from existing structures, 125
dimension
effect on flexural strength, 131
effect on splitting tensile strength, 132-133
making and curing
in field, 72-74
in laboratory, 75
materials conditioning and testing, 75
mixing and testing, 75
moisture
effect on splitting tensile strength, 133

622 TESTS AND PROPERTIES OF CONCRETE

- and temperature effect on flexural strength, 132
 - molded, 124–125
 - preparation, roller-compacted concrete, 575
 - sampling, 72
 - setting time, 124–125
 - size, 73
 - creep effect, 198
 - effect on flexural strength, 131–132
 - effect on splitting tensile strength, 132–133
 - specifications, for molds, 72
 - test data, 73
 - testing personnel, 71–72
 - Texture, aggregates, 406–408, 421–422
 - lightweight, 523–524
 - Thaulow concrete tester, 59
 - Thaumasite, 267
 - Thawing (*see* Freezing–thawing)
 - Thermal coefficient, epoxy system, sand aggregate–binder ratio, 601
 - Thermal conductivity, 229–231
 - aggregates, 441–442
 - cellular concrete, 537
 - determining, 288–289
 - Thermal conductivity methods, water content analysis, 118
 - Thermal cycling, 289–290
 - Thermal diffusivity, 232–233
 - aggregates, 442
 - determining, 288–289
 - Thermal expansion, 10, 233–234, 284–285, 289
 - aggregates
 - determination, 440–441
 - coefficient, 439–440
 - Thermal incompatibilities, 289
 - Thermal neutron activation, cement content analysis, 116
 - Thermal properties, 229–238
 - aggregates, 438–443
 - cement paste component effects, 284–285
 - concepts, 438–439
 - conductivity, 229–231
 - determining, 288–289
 - diffusivity, 232–233
 - expansion, 233–234
 - heat flow, 236–237
 - heat generation and temperature rise, 236
 - heat of hydration, 234–236
 - heavyweight aggregate concrete, 293
 - lightweight aggregate concrete, 293
 - moisture content effect, 290–291
 - refractory concrete, 293–294
 - specific heat, 231–232
 - test methods, 231
 - unit weight and, 309–310
 - very high strength concrete, 293
 - volume and length changes, 237–238
 - winter concreting and insulation, 238
 - Thermal stresses, 292
 - Thermal volume change, 289
 - Thinsets, ceramic tile, latex–modified, 586
 - Thixotropic mixtures, bleeding effects, fresh concrete, 94
 - Torsional strength, 134
 - Toughening, hardened fiber–reinforced concrete, 554
 - Trace elements, hydraulic cements, 471
 - Transporting
 - roller-compacted concrete, 572–573
 - test specimens, 74
 - Truck mixing, ready mixed concrete, 517
 - Tuff, petrographic examination, 357–358
 - Tuthill–Cordon test procedure, 78–79
 - Two-point workability test, 61–63
 - Type K cement, drying shrinkage, 224–225
- U**
- Uniformity, 31–33, 35–37
 - ASTM C 917, 33, 35
 - batch-to-batch variations, 50
 - guidelines for future standards, 35–37
 - measurement, 50–53
 - production, 50–53
 - unit weight and, 309
 - within-batch variations, 50
 - Uniform seepage, 90
 - Unit weight, 308–311, 422–423
 - aggregate density effect, 311
 - air content and, 297, 311
 - definition, 422–423
 - degree of consolidation, 309
 - fresh fiber–reinforced concrete, 550
 - hardened concrete, determining, 310–311
 - inferring batch weights and composition, 310
 - lightweight aggregates, 524
 - measurement
 - fresh concrete, 65
 - gravimetric method, 69
 - paste content effect, 311
 - permeability, 309
 - significance, 308–311
 - thermal, acoustic, and nuclear shielding properties, 309–310
 - typical values, 310
 - uniformity and, 309
 - voids content, 309
 - Unit weight test, 51
 - U.S. Army Corp of Engineers, method of test for concrete mixer performance, 51
 - USBR 4907, 232
 - USBR 4908, 270, 272
 - USBR 4909, 232
 - USBR 4910, 234
 - USBR 4911, 236
 - U.S. Bureau of Reclamation, test of mixer performance, 50
- V**
- Vapor diffusion, 249–250
 - Vebe apparatus, 59
 - Vermiculite, exfoliated, petrographic examination, 358
 - Vibration, air void expulsion, 488
 - Volcanic cinders, petrographic examination, 357–358
 - Volume change (*see also* Expansion), 219–227
 - autogenous, 219–220
 - bleeding, fresh concrete, 92–93
 - carbonation shrinkage, 220–222
 - drying shrinkage, 222–224
 - expansion due to hydration of free CaO and MgO, 224, 226
 - expansive cements, 224–225
 - hydraulic cements, 455–456
 - roller-compacted concrete, 574
 - setting time and, 78
 - test methods, 225–227
 - thermal, 289
 - thermal properties and, 237–238
 - Volumetric method, air content of fresh concrete, 68–69
- W**
- Washington degradation test, 392
 - Waste materials, cellular concrete, 534
 - Water
 - absorption, 253
 - aggregates, 423–424
 - cellular concrete, 537–538
 - measurement validity, 426–428
 - addition to ready mixed concrete, 517–518
 - classification, in gel, 243
 - in concrete, 5–6
 - content
 - analysis, fresh concrete, 52
 - effect on bleeding, 101–102
 - curing, 476–477
 - mixing (*see* Mixing water)
 - municipal, analysis, 474
 - penetration, 253–254
 - permeability testing and standards, 253–254
 - quality, ready mixed concrete, 514
 - in shotcrete, 593–594
 - thermal conductivity, 230
 - Water/cement ratio
 - air content and, 487
 - bleeding effect, 90–92, 94, 101–102
 - drying shrinkage and, 223
 - permeability and, 168–169
 - hardened cement paste, 245, 255–257
 - porosity, 297
 - ready mixed concrete, 513
 - setting time and, 83, 85
 - Water content
 - analysis, 117–119
 - ASTM C 1079, 117
 - capacitance methods, 118
 - concrete consistency method, 118
 - Dunagan Bouyancy Method, 118
 - electrical resistance, 118–119
 - flotation method, 118
 - microwave–absorption method, 119
 - microwave oven separation method, 118
 - neutron–scattering methods, 119
 - thermal conductivity methods, 118
 - determination, 318
 - Water gain (*see* Bleeding)
 - Water-reducing admixtures, 492–493
 - applications, 494–495
 - high-range, 493–494
 - roller-compacted concrete, 571
 - Wear, aggregates, 396–398
 - Weather (*see* Environment)
 - Weathering processes (*see also* Freezing–thawing), 161–162
 - effect on acrylic–modified mortar adhesion, 582
 - salt, 276
 - Weeping (*see* Bleeding), 88
 - Weight loss, 158
 - Wet abrasion tests, aggregates, 391–394
 - Wet–mix delivery equipment, shotcrete, 592
 - Wigmore consistometer, 59–60
 - Willis and Hime Separation Method, cement content analysis, 51, 115
 - Windsor probe test system, 328–329
 - Wood, problems incidental to use, 178
 - Workability, 49–63
 - air content and, 51, 297
 - air entrainment and, 54
 - cement and, 53–54
 - chemical admixtures and, 54–55
 - coarse aggregate and, 54
 - consistency and, 54
 - definition, 53
 - fiber effect, 547
 - finely divided material and, 54
 - fresh fiber–reinforced concrete, 548–550
 - measurement, 55–63
 - ball penetration test, 58–59
 - compacting factor, 59–60
 - flow cone, 60–61

grout consistency meter, 60–62
K-slump tester, 55–57
Otto Graf viscosimeter, 61–62
placeability, 57
rational measure, 44
remolding test, 58
slump test, 55
Thaulow concrete tester, 59
two-point workability test, 61–63

Vebe apparatus, 59
Wigmore consistometer, 59–60
mixing-and-placing porosity, 246
mixture proportions and, 55
recycled concrete aggregates, 180
sand and, 54
terminology, 49

X

X-ray fluorescence, hydraulic cements, 469

Y

Yield

air content and, 297, 311
fresh fiber-reinforced concrete, 550
ready mixed concrete, 512

Z

Zinc, corrosion, 169, 177