A

abutment scour. 836 accurate method, 584 acoustic impedance, 153 active retaining walls, 716-717 active zone, 478, 597 activity (soil parameter), 57 adobe, 88 adsorbed water layer, 29 aeolian soil, 88 aggregate columns, 946 air air entry value, 270 air permeability test (for unsaturated soils), 214-215 flow of, in unsaturated soil, 382-388 in situ air sparging (ISAS), 888 allowable stress design (ASD), 490 alluvial fans, 20 alluvium, 20, 88 American Society for Testing and Materials (ASTM), 49 anchor bond length, 741 anchored walls, 735-746, 805 anchoring length, 919 anchors, retaining walls and, 740-742 angle of repose, 651 antennas, 162 anticlines, 19 approach velocity, 842 aquifer, 22 area ratio factors, 253-254 artesian pressure, 21 artificial neural network (ANN) method, 314-315 associated displacement retaining walls, 716-717 associated flow rule, 352 ASTM Procedure, 884-885

atomic absorption spectrophotometry (AAS), 876 at-rest earth pressure, 724–725 attenuation relationship, 790 Atterberg, Albert, 53 Atterberg limits, 49, 53–56 augercast piles, 557 automatic hammers, 104 Avogrado, Amadeo, 874 Avogrado number, 874 axisummetric heat propagation, 474–475

B

backward erosion, 852 band drains, 943 Barcelona Basic Model (BBM), 355-357 Barentsen, Pieter, 107 base grouting, 555 base instability, retaining walls and, 738 bathymetry, 94 battered piles, 553 BCD test, 126-127, 184 bearing capacity, 918 bells, 555 bender elements, 180-181 bentonite, 88 Bessel correction, 306 Biaud-Tucker SPT method, for driven piles in coarse-grained soils, 580 bioremediation (BR), 889-890 Bishop simplified method, 664-665 block analysis, 654 block failure, 588-589 body wave magnitude, 784 Boltzmann, Ludwig, 349 bored piles, 553, 555-558. See also pile installation borehole in situ tests, 127-129

borehole shear test (BST), 117-119 borings field identification and boring logs, 87-88 site investigation, drilling, and sampling, 80-81 bottom barriers, 886-887 bottom-up retaining walls, defined, 716 bottom-up slopes, manmade, 918 boundary element method (BEM), 304 Boussinesg, Joseph, 2 Boutwell, Gordon, 131 bracketed duration, 789 Brazos River meander case history, 845-847 breaking the soil, 909 bridge scour case history, 841-844 defined, 831 explained, 831-841 Buckingham ∏ theorem, 315–316 bulbs of pressure, 509 bulk modulus, 346 buoyancy, underwater foundations and, 582 buoyancy force, 33 burping the tremie, 555

С

calcareous sands, 88 calcium oxide, 952 caliche, 88 California bearing ratio test (CBR), 122 Cam Clay model, 354-355 cantilever, 727 cantilever edge distance, 518 cantilever gravity, 727 cantilever retaining walls, 805 cantilever top-down walls, 732-735 capillary zone, 423 CAPWAP method, 570 Case Method, 568-569 Cassagrande, Arthur, 58, 185, 186 cations, 28 Celsius, 6, 472 Celsius, Anders, 472 cement, 949 cementation, 403 centrifuge model, similitude laws application, 317-318 characteristics, 281 characteristic site period, 793 characteristic value, 491 chart approach, 506-507

chemical grouting, 950 chilled mirror psychrometers, 176-177 classification parameters, soil, 56-57, 58 clastic rocks, 68 clay composition, 27-28 clay liners, geosynthetic, 910-911 clear water scour, 831 cliff. 19 code approach, earthquake geoengineering, 795–797 Code of Federal Regulations, 873 cohesive soils, 453 collapse deformation behavior, 424-425 collapse test, 193 collapsible soils, 19, 88 colluvial fans, 20 colluvium. 88 combined piled raft foundation (CPRF), 609-612 compaction dynamic or drop-weight compaction, 707-710 earth pressure retaining walls due to, 725-726 field tests, 700 generally, 698 impact roller compaction, 706-707 intelligent roller compaction, 701-706 laboratory tests, 698-700 soil improvement and, 938 soil type and, 701 compaction control tests BCD test, 126-127 field oven test, 125-126 generally, 124 lightweight deflectometer (LWD) test, 126 nuclear density/water content test, 125 rubber balloon test (RBT), 124-125 sand cone test (SCT), 124 See also compaction test compaction grouting, 950 compaction test dry unit weight, 181-184 soil modulus, 184-185 compensation grouting, 950 Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), 874 compressible inclusions, 922 compression index, 407-408 compressive strength, 443 concentrated leak, 852 concrete shear strength properties and, 448 soil improvement and, 949 conduction, 472

cone penetration test (CPT), 107-111 cone penetrometer dissipation test (CPDT), 129 confinement effect, 403 conservation of mass, 370 consolidated undrained direct shear test (CUDS), 450-451 consolidated undrained simple shear test (UUSS), 450-451 consolidation settlement magnitude, 510-511 time rate, 511 consolidation test compression index, recompression index, and secondary compression index from, 407-408 defined, 185-190 preconsolidation pressure and overconsolidation ratio from, 413-416 time effect from, 416–418 constant gradient procedure, 188 constant head permeameter test, 209-212 constant rate of strain procedure, 188 constitutive laws, 280 constrained modulus, 346 contaminants, types of, 872-873. See also geoenvironmental engineering continuous bridge, 522 continuous control compaction, 701 contractile skin, 256, 257-258 contraction scour, 835 contractive soil, 30, 129 convection, 472 conventional compaction, 698 coring, of rock, 73 Coulomb, Charles, 2, 717 Coulomb earth pressure theory, 717-719 course-grained soils, shear strength properties and, 448-449, 451-452 covers, for landfills, 893 covers, geosynthetics, 913-915 crack openings, 676 creep, 348, 407-408 creep compliance function, 348-349 creep settlement, 511-513 critical circle, 667 critical damping, 787 critical hydraulic gradient, 374-375 critical plane, 652 cross hole sonic logging, 558 cross hole test, 155–156 cross-plane, 907 cryosuction process, 479 Culman, Carl, 2

cumulative distribution function, 306 cyclic loading effect, 583, 604–605 cyclic modulus, 401 cyclic stress ratio (CSR), 797 cylindrical coordinates, 250–251

D

damper, 347-348 Daniel, David, 130 Darcy, Henry, 2, 371 Darcy's Law, 130, 318, 371-372, 880 dashpot, 347-348 Da Vinci, Leonardo, 2 deconvolution, 794 deep cement mixing, 951 deep foundations combined piled raft foundation (CPRF), 609-612 design strategy, 553-555 downdrag, 592-597 horizontal load and moment, pile group, 606-609 horizontal load and moment, single pile, 598-606 pile installation, 555-575 piles in shrink-swell soils, 597-598 seismic design, 806-807 types of, 553 vertical load, pile group, 587-591 vertical load, single pile, 575-587 deep soil mixing, 951 deep water, 833 deformation properties collapse deformation behavior, 424-425 common values of Young's modulus and Poisson's ratio, 406-407 compression index, recompression index, and secondary compression index from consolidation test, 407-408 correlations with other tests, 408 deformation problems, solving, 283-286 generally, 401 initial tangent modulus (G_{max}), 411–412 modulus, defining, 402 modulus, modulus of subgrade reactions, and stiffness, 405-406 modulus, time effect, and cyclic effect from pressuremeter test, 418-419 modulus and differences between fields of application, 405 modulus and influence of loading factors, 403-405 modulus and influence of state factors, 402-403 modulus as comprehensive model, 408-411 modulus of deformation, generally, 401-402

deformation properties (continued) preconsolidation pressure and overconsolidation ratio from consolidation test, 413-416 reduction of G_{max} with strain (G/G_{max} curve), 412–413 resilient modulus for pavements, 419-420 shrink-swell deformation behavior, shrink-swell modulus, 422-424 time effect from consolidation test, 416-418 unsaturated soils and effect of drying and wetting on the modulus, 420-422 dense nonaqueous phase liquids (DNAPLs), 877 depth of compaction, 709 design methods, prediction methods versus, 583-584 deterministic analysis, 312 diagenetic bonds, 453 dielectric constant, 162 diesel hammers, 560 diffusivity, 473 dikes, erosion and, 847-850 dilatancy test, 87 dilatant, 129 dilatant structure, of soil, 30 dilatometer test (DMT), 114-115 dimensional analysis, 315-316 dip, 19 direct current differential transformer (DCDT), 179 direct shear test, 193-195 direct strength equations, 491-494 discharge velocity, 211, 370 discounted anchor length, 741 discrete element method (DEM), 304-305 dispersed structure, of soil, 30 dispersion curve, 159 dispersive clays, 88 displacement-replacement technique, for soil improvement, 941 displacements, 249 downdrag, 592-597 drainage, geosynthetics and, 907, 919 drained analysis, 463, 669 drawing, to scale, 280 drilled piers, 553, 555 drilled shafts, 553, 555 drilling hollow stem auger drilling method, 82-83 wet rotary drilling method, 81-82 See also site investigation, drilling, and sampling Drucker-Prager criterion, 351 dry soil, 26 dry strength test, 87 dry unit weight, 31, 181-184

Duncan-Chang model (DC model), 353–354 dunes, 20 durability, 72–73 dynamic compaction, 698 dynamic finite element analysis, 676 dynamic replacement (DR), 948 dynamic soil properties, earthquake geoengineering, 786

Е

earth dams, internal erosion of, 851-854 earth pressure retaining walls at-rest earth pressure, 724-725 defined, 716-717 due to compaction, 725-726 earth pressures in shrink-swell soils, 726 theories, 717-723 earthquake geoengineering design parameters, 794-797 earthquake, defined, 784 earthquake magnitude, 784-786 generally, 784 ground motion, 786-789 ground response analysis, 792-794 liquefaction, 797-801 seismic design of foundations, 806-807 seismic design of retaining walls, 802-805 seismic hazard analysis, 789-792 seismic slope analysis, 674-676 seismic slope stability, 801 seismic waves, 151-153 edge drop, 518 edge lift, 518 effective stress analysis, 463 saturated soils, 253 unsaturated soils, 252-253 effective stress analysis, 669 effective stress cohesion intercept, 451 effective stress method, for driven piles in fine-grained soil, 580 effective stress principle, 3 effective unit weight, 31 Eiffel Tower, 5, 528 elasticity defined, 345-347 deformation properties and, 401 elasticity approach for homogenous soils, shallow foundations, 504 elasticity approach for layered soils, shallow foundations, 504-506 electrical double layer, 29

electrical resistivity techniques, 160-161 electric pulse compaction, 940 electromagnetic methods electromagnetic waves, 161-162 ground-penetrating radar (GPR), 162 time domain reflectometry (TDR), 162-165 electro-osmosis, 945 end-bearing piles, 553 engineering geology, generally defined, 15 Earth and universe age, 15 geologic features, 19-20 geologic maps, 20 geologic time, 15–17 groundwater, defined, 20-22 rocks, defined, 17 soil creation, 17-19 Environmental Protection Agency, 873, 882, 883-884 environmental site assessments (ESAs), 877 epicenter, 784 epicentral distance, 784 equilibrium equations, for two-dimensional analysis (calculating stresses), 246-247 Erdbaumechanik (Terzaghi), 2 erosion control, geosynthetics, 920-921 erosion of soils and scour problems bridge scour, 831-841 countermeasures for erosion protection, 850-851 erosion function, measuring, 824-825 erosion models, 824 erosion phenomenon, 823-824 internal erosion of earth dams, 851-854 levee overtopping, 847-850 river meandering, 844-847 rock erosion, 826-829 soil erosion categories, 825-826 water velocity, 829-831 Woodrow Wilson Bridge case history, 841-844 erosion test, 215-218 error function, 307 escarpments, 19 excess pore pressure, 286 exit gradient, 380 expansive soils, 88 expected earthquake, 794 explosive compaction, 940

F

factor of safety, 76 failure (geomembrane), 908

failure problems, solving, 281-283 falling head permeameter test (for saturated soils), 212-213 fate, contaminant transport and, 880 faults, 19, 71, 784 FEM approach, 745–746 FHWA method for bored piles in coarse-grained soils, 578-580 for bored piles in fine-grained soils, 578 field oven test, 125-126 field values of hydraulic conductivity, lab values versus, 373 fill, preloading using, 941-943 filter paper method, water tension stress, 174-175 filter soil, 854 filtration, 907, 919 fine-grained soils, shear strength properties and, 453-456 finite difference method (FDM), 289-294 finite element method (FEM), 294-304, 674 first load modulus, 401 fissures. 71 fixed-head condition, 602-603 floating foundation, 523 flocculated structure, of soil, 30 floodplain deposits, 19 flow channel, 377 flow field. 377 flow net calculations for, 379-381 defined, 377 drawing, for homogenous soil, 377-378 flow and, for layered soils, 381-382 for hydraulically anisotrophic soil, 380-381 properties of, for homogenous soil, 378 flow of fluid/gas generally, 370 water and air in unsaturated soil, 382-388 water in saturated soil, 370-382 flow path, 371 flow problems, solving, 286-289 flow rule, 352 folds, 19 foundations. See deep foundations; shallow foundations foundations, geosynthetic, 918-919 Fourier, Jean Baptiste Joseph, 787 Fourier, Joseph, 473 Fourier acceleration spectrum, 787-789 Fourier's Law, 473 Fourier spectrum, 787 free-head condition, 602-603 free span distance, 518 free swell, 55

free swell limit, 422 friction piles, 553 frozen soils, 478–479 fundamental laws, 280

G

gamma-gamma logging, 558 gas, generated by landfills, 895 general bearing capacity equation, 494-496, 499 generalized equilibrium method, 665-667 geobags, 904 geocells, 904 geochemistry background, 874-877 defined. 876 See also geoenvironmental engineering geocomposites, 905 geoenvironmental engineering contamination, 877-883 future considerations, 895-896 generally, 872 geochemistry background, 874-877 landfills, 890-895 laws and regulations, 873-874 remediation, 872, 883-890 types of wastes and contaminants, 872-873 See also geosynthetics geofoams, 904 geogrids, 904 geologic maps, 20 geologic time, 15–17 geomembranes, 904, 908, 913. See also geosynthetics geometry of the obstacle, 831 geonets, 904, 912 geophysics, elements electrical resistivity techniques, 160-161 electromagnetic methods, 161-165 generally, 151 remote sensing techniques, 165-166 seismic techniques, 151-159 geosynthetics clay liners, 904 compressible inclusions, 922 defined, 904 erosion control, 920-921 filtration and drainage, 919-920 geosynthetic mat and column-supported embankment, 953-955 landfill slopes, 922 lightweight fills, 922

liners and covers, 913-915 properties of, 905-913 reinforcement, 915-919 thermal insulation, 922 types of, 904-905 geotechnical centrifuge, 317-318 geotechnical engineering, generally defined, 1 failures, 5 foundations, 5 as fun. 5 past and future of, 2 recent and notable projects, 2-5 units of measure, 5-10 geotextiles, 904 governing differential equation (GDE), 882 Gow, Charles, 104 grains, 26 gravel composition, 27 particle size, shape, color, 26-27 gravimetric water content, 31-32 gravity walls, 727-729, 802-804 ground, 938 ground freezing, 945 ground motion, earthquake and, 786-789 ground-penetrating radar (GPR), 162 ground response, 792 ground response analysis, 792 ground rolls, 153 groundwater defined, 20-22 deformation properties and, 423 groundwater table, 20 remediation, geoenvironmental engineering, 888-890 site investigation, drilling, and sampling, 85-87 water stress conditions and, 679 (See also slope stability) group velocity, 157 grout, 949 grouted barriers, 885 grouting techniques, for soil improvement, 948-953

H

hand shaking test, 87 hand tampers, 698 Handy, Richard, 117 hardening rule, 352–353 hardness (rock), 73 harmonic functions, 377 hazard level, 797

heads, of water, 371 head (water), 371 heat conduction theory, 473-474 heat flow, 472 heat transfer rate, 472 heave and critical block, 380 high air entry porous stone, 173 histogram, 304 hollow stem auger drilling method, 82-83 hurricanes defined. 850 Hurricane Katrina levee case history, 848-850 hydration, 949 hydraulic conductivity defined, 371-372 of saturated soils, 371-373 of unsaturated soils, for water and for air, 382-384 hydraulic conductivity field tests borehole tests, 127-129 cone penetrometer dissipation test (CPDT), 129 generally, 127 sealed double-ring infiltrometer test (SDRIT), 130-131 two-stage borehole permeameter test (TSBPT), 131-132 hydraulic gradient, 371 hydraulic hammers, 560 hydro-blasting compaction, 945 hydrograph, 830 hydrometer analysis, 49, 50-53 hypocenter, 784

I

ice lenses, 479 igneous rocks, 17, 68 impact hammers, 560 impedance log, 560 impulse response method, 559-560 incremental loading procedure, 185 independent stress state variables, 264 inertial interaction, 806 initial tangent modulus (G_{max}) defined, 411-412 reduction of G_{max} with strain (G/G_{max} curve), 412–413 inliers, 19 in-plane, 907 in situ air sparging (ISAS), 888 in situ flushing, 888 in situ tests, 80-81 borehole shear test (BST), 117-119 California bearing ratio test (CBR), 122 compaction control tests, 124-127

cone penetration test (CPT), 107-111 dialatometer test (DMT), 114-115 generally, 104 hydraulic conductivity field tests, 127-132 offshore, 132-134 plate load test (PLT), 119-122 pocket erodometer test (PET), 123-124 pocket penetrometer test (PPT), 122-123 pressuremeter test (PMT), 111-114 shear strength properties and, 450-452 soil modulus and correlation with, 408 standard penetration test (SPT), 104-107 torvane test (TVT), 122-123 vane shear test (VST), 115-117 in situ waste containment, 885 intelligent compaction, 698, 703 interaction factor method, 590 interface shear stress, 829 International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE), 49, 174, 609 ions, 160 ironing, 708 isomorphous, defined, 28 isomorphous substitution, 28

J

Janbu chart, 658–659 jet grouting, 950 joints, 71 Joule, James Prescott, 472 joules, defined, 472 jumping jacks, 698 junction strength, 909

K

karst, 19 Kelvin, 6, 472 Kelvin-Voigt model, 347–348 Khalili rule, 717 kilogram, 5 kilo-Newton, 10 kilo-Pascal, 10 kinematic interaction, 806

L

laboratory tests air permeability test for unsaturated soils, 214–215 collapse test, 193

laboratory tests (continued) compaction test, dry unit weight, 181-184 compaction test, soil modulus, 184-185 consolidation test, 185-190 constant head permeameter test, 209-212 direct shear test, 193-195 erosion test, 215-218 falling head permeameter test for saturated soils, 212-213 generally, 172 lab vane test, 206 measurements, 172-181 resonant column test, 202-206 shrink test, 192-193 simple shear test, 195-196 soil water retention curve (soil water characteristic curve) test, 206-209 swell test, 190-192 triaxial test, 198-202 unconfined compression test, 196-198 wetting front test for unsaturated soils, 213-214 lab values of hydraulic conductivity, field values versus, 373 lab vane test, 206 lacustrine deposits, 88 landfills, 890-895 Laplace equation, 377 latent heat, 475 laterite, 88 leachate collection, 893-894 levee overtopping, erosion and, 847-850 LIDAR (laser radar), 165 light nonaqueous phase liquids (LNAPLs), 876-877 lightweight deflectometer (LWD) test, 126 lime, 952 limit pressure, 353 limit states defined, 488-489 limit state design (LSD), 490 limit state function, 488 linear elasticity, 401 linear viscoelasticity, 347-349 liners, geosynthetic, 904, 913-915 liquefaction earthquake geoengineering, 797-801 sand liquefaction, 375 liquidity index, 57 liquid limit, 53 live bed scour, 831 load cyclic loading effect, 604-605 horizontal load and moment, pile group, 606-609 horizontal load and moment, single pile, 598-606

load and resistance factor design (LRFD), 490, 595-596 loading-collapse curve (LC curve), 356 loading rate, undrained strength and, 456 load settlement curve approach, 500-502 normal compression loading (NCL) curve, 355 one-way cyclic loading, 583 plate load test (PLT), 119-122 rate of loading effect, 603-604 surface loading and retaining walls, 722-723 testing, pile installation, 571-575 vertical load, pile group, 587-591 vertical load, single pile, 575-587 See also deep foundations; shallow foundations loam, 89 loess, 89 long flexible pile, 599-601 longitudinal distortion, 522 long-term analysis, 463, 669 love waves, 153 LPC-CPT method, 578 LPC-PMT method, 576-578

Μ

machine drive power, 705 major principal stress, 245 manometer, 173 Marchetti, Silvano, 114 marl, 89 mat foundation defined, 385 large mat foundations, 523-528 matric suction, 256-257 maximum dry density, 183 maximum shear stress, scour and, 837-839 Maxwell, James, 348 Maxwell model, 347-348 meandering, by rivers, 844-847 MEANDER method, 844 meander migration, 19 mechanically stabilized earth (MSE) walls, 729-732, 805, 915-918 mechanical waves, 161 Menard, Louis, 111 metamorphic rocks, 17, 68 meter. 5 methane, 895 method of slices, 661-667 Michelangelo, 2 microbial methods, for soil improvement, 952 micropiles, 557

minor principal stress, 245 Mississippi River, locks and dams of, 3 mixing method, for grouting, 951-952 mobility, 559 Modified Cam Clay (MCC) model, 354-355 Modified Proctor Compaction Test (MPCT), 181, 183–184 modulus of deformation. See deformation properties modulus of elasticity, 345-347 modulus of subgrade reaction, 405-406, 602 Mohr, Otto, 2, 247, 350 Mohr circle earth pressure theory, 720-721 in three dimensions, 248 for two-dimensional analysis, 247-248 Mohr-Coulomb yield criterion, 350 moment magnitude, 785 monitored natural attenuation (MNA), 889 montmorillonite, 89 Morgenstern chart, 659-661 mortar, 949 movement at depth in the slope, 676 movements of the slope surface, 676

Ν

National Geotechnical Experimentation Site, Texas A&M University, 485 natural unit weight, 31 negative pore pressure, 251 net increase in stress, 524 net settlement, 524 neutral point, 592 Newmark's chart, 509-510 Newmark's displacement method, 675-676 Newton, 6, 10 nodes, 289 nonaqueous phase liquids (NAPLs), 876-877 nonclastic rocks, 68 nondestructive testing (NDT), 558 nondispersive material, 157 normal compression loading (NCL) curve, 355 normality rule, 352 normal strain, 179-180, 249-250 normal stress, 245-246 nuclear density/water content test, 125 numerical simulation methods boundary element method (BEM), 304 discrete element method (DEM), 304-305 finite difference method (FDM), 289-294 finite element method (FEM), 294–304 numerical solutions, defined, 289

0

offshore site investigations generally, 89-94 geophysical investigations, 94-95 geotechnical drilling, 95-98 geotechnical sampling, 99 in situ tests, 132–134 one-dimensional flow, 384-386 100-year flood, 830 one-way cyclic loading, 583 optimum water content, 183 organic clay/silt, 89 osmosis, 30 osmotic suction, 258 Osterberg load cell test, 572-573 outcrops, 19 outliers, 19 overconsolidated soil, 403, 448, 455 overconsolidation ratio (OCR), 408 overturning moment, 554, 607

P

Panama Canal, 3 particles, of soil. See soil components particle velocity, 151–152 particulate grouting, 949 passive earth pressure retaining walls, 716-717 peak ground acceleration (PGA), 786 peak ground displacement (PGD), 786 peak ground velocity (PGV), 786 peat, 89 peel strength, 911 perched water, 22 permafrost, 20, 478 permanent set, 561 permeability, 373 permeance (geomembrane), 908 phase velocity, 157 phicometer, 119 phreatic surface, 21, 87, 667 pier scour, 832-834 piezometric surface, 21, 667-668 pile driving analyzer (PDA), 568-569 pile installation of bored piles, 555-558 information from pile driving measurements, 566-570 installation of driven piles, 560-561 load testing, 571–575 nondestructive testing of bored piles, 558-560 pile driving formulas, 561-562

pile installation (continued) suction caissons, 570-571 wave equation analysis, 563-566 wave propagation in a pile, 562-563 piston samplers, 85 plane strain, 346 plane stress. 346 plasticity, 349-353, 353. See also soil constitutive models plasticity index, 53, 57, 58, 513 plastic limit, 53 plastic potential function, 352 plate load test (PLT), 119-122 plugging, 99 pocket erodometer test (PET), 123-124 pocket penetrometer test (PPT), 122-123 Poisson's ratio, 73, 401-402, 406-407, 581-582. See also deformation properties Pole method, 247-248 polyaromatic hydrocarbons (PAHs), 882 polychlorinated biphenyls (PCBs), 876, 882 pore-pressure parameters (A and B), 458-459pores, 26 pore water pressure, 173 positive pore pressure, 251 potential vertical rise (PVR) method, 514 precise method, 584 prediction methods, design methods versus, 583-584 prefabricated vertical drains (PVDs), 943-944 preloading using fill, 941-943 using vacuum, 943-944 pressuremeter test (PMT), 111-114, 418-419 pressure plate apparatus (PPA), 177-178 principal planes, 245 probability and risk analysis background, 305-308 probabilistic approach, 305 procedure for probability approach, 308-310, 312-313 risk and acceptable risk, 310-312 problem-solving methods artificial neural network (ANN) method, 314-315 continuum mechanics methods, 281-289 dimensional analysis, 315-316 drawing to scale and, 280 generally, 280 numerical simulation methods, 289-305 primary laws, 280 probability and risk analysis, 305-313 regression analysis, 313-314 similitude laws for experimental simulations, 317-319 types of analyses, 319

Proctor, Ralph, 181 progressive failure, 669 pseudostatic method, 674–675 psychrometers, 176–177 pull-out design, retaining walls and, 730–732, 748–749 pump and treat, 888 punching, 913 P waves, 152 P-y curve approach, 605–606, 733–735, 745–746

Q

quantity of flow, 379 quick clay, 89, 375 quick sand, 89, 374–375

R

radar satellite, 165 radiation, 472 raft foundations, 523 rammed aggregate pier method, 946 rams, 560 Rankine, William, 2, 719 Rankine earth pressure theory, 719-720 rapid impact compaction, 940 rare earthquake, 794 rate of loading effect, 603-604 Rayleigh waves, 153, 157 recompression index, 407-408 recovery ratio, 73 recurrence interval, 791 reflection, seismic, 153-154 refraction, seismic, 154-155 refractive index, 154 regression analysis, 313-314 relative humidity, total suction and, 258-260 relaxation, 348 relaxation modulus function, 348-349 reliability index, 306 remediation, geoenvironmental engineering, 872, 883-890 remolded shear strength, 446 remote sensing techniques, 165-166 replacement. See soil improvement residual shear strength, 446 residual soils, 89 residual strength, 461 residual stresses, 567 resilient modulus, 402, 419-420 resistivity tomography, 160-161 resonant column test, 202-206

response spectrum, 787 retaining walls active, at rest, passive earth pressure, and associated displacement, 716-717 anchored walls and strutted walls, 735-746 at-rest earth pressure, 724-725 bottom-up, defined, 716 cantilever top-down walls, 732-735 displacements, 726-727 earth pressure due to compaction, 725-726 earth pressures in shrink-swell soils, 726 earth pressure theories, 717-723 gravity walls, 727-729 mechanically stabilized earth (MSE) walls, 729-732, 805, 915-918 seismic design of, 802-805 soil nail walls, 746-751 top-down, defined, 716 trenches, 751-752 undrained behavior of fine-grained soils, 723-724 return period, 791 revegetation, 920 Reynolds Number, 216 rib strength, 909 Richter scale, 784 risk analysis geoenvironmental engineering, 883-885 probability and risk analysis, 305–312 rivers Brazos River meander case history, 845-847 contraction scour, 835 river meandering, defined, 844 See also erosion of soils and scour problems river terraces, 20 road reinforcement, geosynthetics and, 815 rock erosion, 826-829 rock mass erosion, 828 rock quality designation, 73 rocks definitions, 17, 68 discontinuities in, 71 permafrost, 76 rock engineering problems, 74-76 rock engineering properties, 72-73 rock groups and identification, 68 rock index properties, 71-72 rock mass, defined, 68 rock mass rating, 73-74 rock mass vs. rock substance, 68-71 rock substance, defined, 68 rock substance erosion, 828

rubber balloon test (RBT), 124–125 rule of the middle third, 729

S

salt solution equilibrium (SSE), 178-179 sampling disturbance, 83-84 methods, 84-85 offshore geotechnical sampling, 99 See also site investigation, drilling, and sampling sand composition, 27 particle size, shape, color, 26-27 sand cone test (SCT), 124 sand liquefaction, 375 San Jacinto Monument, 527-528 satellite imaging, 165-166 saturated flow, 382 saturated soil defined, 26 effective stress, 253 water flow in, 370-382 water stress predictions, 357-358 saturated unit weight, 31 saturation, 784 scaled model, similitude laws application (example), 318 Schmidt hammer, 73 scour problems. See erosion of soils and scour problems sealed double-ring infiltrometer test (SDRIT), 130-131 second, as unit of measure, 5 secondary compression index, 512-513 secondary consolidation, 407-408 secondary recompression index, 407-408 sedimentary rocks, 17, 68 seepage analysis, 668 seepage force, 371, 373-374, 652-653 seepage velocity, 211, 370 seismic cone test, 155-156 seismic dilatometer test, 155-156 seismic hazard analysis, 789-791 seismic reflection, 94, 153-154 seismic refraction, 94, 154-155 seismic slope analysis, 674-676 seismic slope stability, 801 seismic waves, 151-153 separation (geomembrane), 908, 913 service limit state, 489, 502 settlement consolidation settlement, magnitude, 510-511 consolidation settlement, time rate, 511

settlement (continued) creep settlement, 511-513 example of settlement calculations, 524-527 general behavior, 502-504 geosynthetics and, 919 load settlement curve approach, 500-502 of piles, deep foundations, 584-587, 589-591 See also shallow foundations shale, 89 shallow foundations case history, 485 cost of, 553 definitions, 485 definitions and design strategy, 485-488 foundations on shrink-swell soils, 517-522 general behavior, 491 large mat foundations, 523-528 limit states, load and resistance factors, and factor of safety, 488-491 load settlement curve approach, 500-502 seismic design, 806-807 settlement, 502-513 shrink-swell movement, swelling pressures, and collapse movement, 513-517 tolerable movements, 522-523 ultimate bearing capacity, 491-500 SHANSEP method, 456-458 shape function matrix, 295 shear modulus, 346 shear strain, 180, 249-250 shear strength properties basic experiments, 443-445 estimating effective stress shear strength parameters, 451-454 estimating undrained shear strength values, 459-461 experimental determination of shear strength (lab tests, in situ tests), 450-451 generally, 443 pore-pressure parameters A and B, 458-459 residual strength parameters and sensitivity, 461-462 SHANSEP method, 456–458 shear strength, defined, 443 shear strength envelope, 447-449 strength profiles, 462–463 stress-strain curve, water stress response, and stress path, 445 - 447transformation from effective stress solution to undrained strength solution, 463 types of analyses, 463 undrained shear strength for unsaturated soils, 458

undrained shear strength of saturated fine-grained soils, 454-456 unsaturated soils, 449-450, 458 shear stress, 245-246 Shelby tube sampler, 84 short rigid pile, 601-602 short-term analysis, 463, 669 short-term case, 454 shrinkage limit, 53, 57, 513 shrink-swell deformation behavior, 422-424 shrink-swell index, 57, 423-424, 513 shrink-swell modulus, 422-424 shrink-swell movement, shallow foundations and, 513-517, 514 shrink-swell soils deep foundations, piles in, 597-598 defined, 89 earth pressure, retaining walls, 726 foundations on, 517-522 shrink test, 192-193 sidescan sonars, 95 sieve analysis, 49-50 sign convention, for stresses and strains, 246 silt composition, 27-28 particle size, shape, color, 26-27 silt fences, 921 similitude laws, for experimental simulations, 317-319 simple shear test, 195-196 simply supported bridges, 522 sinkholes, 19 site classes, 795 site investigation, drilling, and sampling drilling methods, 81-83 field identification and boring logs, 87-88 generally, 80 groundwater level, 85-87 number and depth of borings and in situ tests, 80-81 offshore geophysical investigations, 94-95 offshore geotechnical drilling, 95-98 offshore geotechnical sampling, 99 offshore site investigations, 89-94 preliminary site investigation, 80 sampling disturbance, 83-84 sampling methods, 84-85 soil names, 88-89 slaking durability test, 72-73 slickensided clay, 89 slopes, geosynthetic, 918

slope stability chart methods, 655-661 design approach, 649-650 finite element analysis, 674 generally, 649 infinite slopes, 650-652 method of slices, 661-667 monitoring, 676-679 plane surfaces, 654 probabilistic approach, 671-672 progressive failure in strain-softening soils, 669 reinforced slopes, 670 repair methods, 679-680 seepage force in stability analysis, 652-653 seismic slope analysis, 674-676 shallow slide failures in compacted unsaturated embankments, 669-670 slopes with water in tensile cracks, 654-655 three-dimensional circular failure analysis, 672-673 types of analyses, 668-669 water stress for slope stability, 667-668 slope stability, landfills, 894-895, 922 slurry trench barriers, 885 Snell's law, 154 softening rule, 352-353 soil, generally creation of, 17-19 soil names, 88-89 (See also soil classification; soil components) stresses in three soil phases, 251-252 (See also stresses and strains) See also saturated soil; unsaturated soil soil cement mixing, 951 soil classification Atterberg limits, 53-56 classification parameters, 56-57 engineering significance of classification parameters and plasticity chart, 58 hydrometer analysis, 50-53 sieve analysis, 49-50 tests for, 49 Unified Soil Classification System, 49, 58-59 soil components composition of clay, silt, 27-28 composition of gravel, sand, silt, 27 particle behavior, 28-30 particles, liquids, and gas, 26 particle size, shape, color, 26-27 saturated, defined, 26 soil structure, 30 three-phase diagram of, 30-31

unsaturated, defined, 26 weight-volume parameters, 31-32 weight-volume parameters, measurement, 32-33 weight-volume parameters, solving problems of, 33-35 soil constitutive models common models, 353-358 elasticity, 345-347 linear viscoelasticity, 347-349 plasticity, 349-353 soil model, defined, 345 soil contact erosion, 852 soil erosion categories, 825-826. See also erosion of soils and scour problems soil improvement generally, 938 with grouting and admixtures, 948-953 with inclusions, 953-955 with replacement, 946-948 without admixture in coarse-grained soils, 938-940 without admixture in fine-grained soils, 941-945 soil modulus, compaction test, 184-185 soil nails, 679 soil nail walls, 746-751 soil remediation, geoenvironmental engineering, 887-888 soil water retention curve (soil water characteristic curve) test. 206-209 soil water retention curve (SWRC), 262-264 sonic echo method, 558-559 soundings, 80-81 sound waves, 152 specific gravity test, 33 specific heat, 473 specific surface, 373 spectral analysis of surface waves, 156 spectral analysis of surface waves (SASW), 156-157, 156-159 Spencer chart, 657-658 spherical coordinates, 250-251 split spoon sampler, 84 spread footing, 485 SPT blow count, 87, 104 staking durability test, 72 standard penetration test (SPT), 33, 104-107 Standard Proctor Compaction Test (SPCT), 181-184 standpipe, 173 standpipe piezometers, 86 static load tests, 571-572 Statnamic load test, 573–575 steam hammers, 560 steel sheet pile barriers, 885-886 stiffened slab on grade, 485, 517-519

stiffness, 906 Stokes, George, 52 Stokoe, Ken, 156 stone columns, 946 strain gages, 180 strain hardening/softening, 353 strain rate, 404 strain tensor, 249-250 stresses and strains area ratio factors, 253-254 calculating stresses on any plane, equilibrium equations for two-dimensional analysis, 246-247 calculating stresses on any plane, Mohr circle for two-dimensional analysis, 247-248 cylindrical coordinates and spherical coordinates, 250-251 displacements, 249 effective stress (saturated soils), 253 effective stress (unsaturated soils), 252-253 generally, 245 independent stress state variables, 264 Mohr circle in three dimensions, 248 net increase in stress, 524 normal strain, shear strain, strain tensor, 179-180, 249-250 precision on water content and water tension, 260 sign convention for stresses and strains, 246 soil water retention curve (SWRC), 262-264 strain rate, 404 strains, defined, 249 stress, defined, 245 stresses in three soil phases, 251-252 stress history factor, 403 stress increase with depth, for shallow foundations, 508-510 stress invariants, 248-249 stress profile at rest in unsaturated soils, 260-262 stress-strain curves, 251 stress vector, normal stress, shear stress, stress tensor, 245-246 water stress profiles, 254-255 water tension and suction, 255-260 See also deformation properties; retaining walls; shear strength properties; soil constitutive models stress-strain curve, 445-447 strip footings, 385 structure, of soil, 30 strutted walls, 735-746 sub-bottom profilers, 95 submerged unit weight, 31 subsidence, 19, 22

Subsurface Contamination Reference Guide (US EPA), 882 suction, 26, 29, 251, 255 suction caissons, 570–571 suffusion, 852 S waves, 152 swelling pressure, 423 swell limit, 34, 191 swell test, 190–192 synclines, 19

Т

TAMU-Slab method, 518-519 Taylor chart, 655-657 tear, 913 temperature gradient, 472 tendon bond anchor, 741 tendon unbonded length, 740, 741 tensiometers, 177 tension strength, 443 Terzaghi, Karl, 2 Texas A&M University, 485 thermal conductivity, 472 thermocouple psychrometers, 176 thermodynamics for soil problems applications, 477-478 axisummetric heat propagation, 474-475 definitions, 472-473 frozen soils, 478-479 generally, 472 heat conduction theory, 473-474 multilayer systems, 476-477 thermal properties of soils, 475-476 thin-wall steel tube, 84 Thompson, William (First Baron Kelvin), 348 thread rolling test, 87 three-dimensional air flow, 387-388 three-dimensional circular failure analysis, 672-673 three-dimensional water flow, 386-387 three-phase diagram, of soil components, 30-31 till, 89 time domain reflectometry (TDR), 162-165 Tokyo Haneda airport, 3 tolerable movement, shallow foundations and, 522-523 top-down retaining walls, defined, 716 torvane test (TVT), 122-123 total (normal) stress analysis, 669 total stress analysis, 463, 669

total unit weight, 31

toughness test, 87 Tower of Pisa, 2, 3, 487-488, 528 toxicity characteristics leaching procedure (TCLP), 876 transverse wave, 162 Trautwein, Steve, 130 trees, osmotic suction and, 260 trenches, retaining walls and, 751-752 Tresca vield criterion, 350 triaxial test, 198-202 true cohesion, 453 tuff. 89 two-dimensional flow problem, 375-377 two-stage borehole permeameter test (TSBPT), 131-132 2 to 1 method, 508 two-way cyclic loading, 583

U

ultimate bearing capacity, 491-500 ultimate capacity, 599, 607-609 ultimate limit state, 489 unconfined compression test, 196-198 unconsolidated undrained triaxial test (UUT), 450-451 underreams, 555 undrained analysis, 463, 669 undrained behavior of fine-grained soils, retaining walls and, 723-724 undrained case, 454 undrained shear strength, 454 Unified Rock Classification System, 73 Unified Soil Classification System, 49, 58-59 unit cell, 953 United States Geological Service, 786 units of measure, 5-10 unit weight of solids, 30 unsaturated flow, 382 unsaturated soil defined, 26 effective stress, 252-253 formation and effect of drying and wetting on the modulus, 420-422 shear strength properties, 449-450, 458 stress profile at rest in, 260–262 three-phase soils, 1 ultimate bearing capacity of, 499-500 water and air flow in, 382-388 water stress predictions, 357–358 uplift force, on buried structures, 380 U.S. Resource Conservation and Recovery Act (RCRA), 891-892

v

vacuum, preloading using, 943–944 Van der Waals forces, 29, 257 vane shear test (VST), 115–117 varved clay, 89 velocity hydrograph, 840 velocity index, 73 vibratory hammers, 560 vibratory rollers, 704–705 vibrocompaction, 938–940 viscous exponent, 122 Voigt, Woldemar, 348 Von Mises, Richard, 351 Von Mises criterion, 351

W

waffle slab, 517, 518 wash hands test, 87 Washington Monument, 2, 525-526, 527-528 wastes, types of, 872-873. See also geoenvironmental engineering water, generally adsorbed water layer, 29 clear water scour, 831 compression stress, 173 deep water, 833 flow of, in saturated soil, 370-382 flow of, in unsaturated soil, 382-388 gravimetric water content, 31–32 perched water, 22 stresses and strains, precision on water content and water tension. 260 stress profiles, 254-255 stress response, 445-447 (See also shear strength properties) tension and suction, 255-260 tension stress, 173-176 water content, defined, 263 water content vs. strain curve, 513-514 water stress, in flow net, 380 water stress predictions, 357-358 water-vapor transmission, 908 wave amplitude, 152 wave equation analysis, 561, 562-566 wave frequency, 152 wave velocity, 151 weight-volume parameters generally, 31-32 measurement, 32-33

weight-volume parameters (*continued*) solving problems of, 33–35 *See also* soil components wet rotary drilling method, 81–82, 112 wetting front test (for unsaturated soils), 213–214 wick drains, 943 wide width strength, 909 Woodrow Wilson Bridge, 841–844 work hardening/softening, 353 working stress design (WSD), 490 World Trade Center, 74–76, 528

Y

yield horizontal seismic coefficient, 675 yielding, of soil, 350–352 yield stress, 448 Young, Thomas, 345, 401 Young's modulus, 345–347, 401, 406–407. *See also* deformation properties

Z

zone of influence, 507-508