

Index

A

- Alembert, Jean d', 76
- Alexander the Great, 34, 38
- American Association of State Highway and Transportation Officials (AASHTO), 92, 101, 159, 550
- allowable stress design (ASD), *see* Design, AASHTO specifications
- bridge useful life (nominal), 101, 351, 392
- condition evaluation, *see* Structural condition
- construction specifications, 188, 270
- core elements (CoRe), 325, 334, 348, 609
- design loads, *see* Load, design (AASHTO)
- design specifications, *see* Design, AASHTO specifications
- Load and Resistance Factor Design (LRFD), *see* Load, design
- load rating, *see* Load, rating (AASHTO)
- maintenance, *see* Maintenance
- on extreme events, *see* Load, extreme events
- on failure modes, *see* Failure, modes and mechanisms
- road test, 337
- seismic provisions, *see* Load, extreme events
- American Railroad Engineering and Maintenance Association (AREMA), 92, 101, 222, 323, 344, 362, 365, 437, 448, 591–592, 610–612
- American Society of Civil Engineers (ASCE), 82, 100, 188, 229, 427
- design specifications, *see* Design
- quality of the constructed product, 453
- Ammann, Othmar, 15, 18–19, 27–29, 82, 140, 144, 233, 579
- Analysis, 3, 14, 16, 79, 81, 120, 125, 313–315, 331
- analytic tools of management, 555–559
- cost and benefit, 100, 162, 182, 315, 378, 402–411
- decision making, 81, 84, 414–422, 536
- deterministic, 74, 242, 418
- economic, 93, 293, 398–411, 573–574
- failure, 123, 126, 434. *See also* Failure forensic, 123
- life-cycle cost (LCCA), 94, 160, 163–166, 314–316, 349, 376–380, 399–419, 550, 599–600, 604
- of inelastic frames, 548
- of organizations, 541
- of uncertainty, 536, 539–540. *See also* Uncertainty
- present worth, 163–170, 182, 408, 604
- probabilistic, 192, 242, 398
- risk, 84, 101, 292, 300, 339, 602
- spectral, 175
- stability, 193, 578–588
- statistical, 44, 154, 184
- stochastic, 192, 300, 371, 546–547
- structural (stress), 91, 129–138, 157–158, 186, 187–285, 300–305, 344, 362, 366, 454–458, 496–498, 503. *See also* Load, rating
- system, *see* System, analysis
- Archimedes, 4–5
- Aristotle, xi, 4–6, 9, 34, 42, 70–71, 74, 107–108, 507
- Asimov, Isaac, 67, 412, 537
- Assessments, 326–335
- of needs, *see* Needs
- of networks and projects, 326–367, 436
- of product and process, *see* Quality Assurance & Quality Control
- of risk, *see* Analysis, risk
- of structural conditions, *see* Needs; Structural condition

Asset management, 72, 100, 159, 184, 316,
327, 369, 415–421
definition (FHWA), 398
definition (U.K.), 415
integrated, 421, 431, 550, 565
system, *see* System, asset management

B

Barzun, Jacques, 11, 15

Bayes, Thomas, 75

Bayesian, *see* Reliability, Bayesian

Berlin, Isaiah, 41–42

Billington, David, 8, 14, 17, 27, 45, 47, 54,
165, 171, 188

Boller, Alfred P., 15, 18, 92, 165, 187, 190,
208, 273, 379, 392

Born, Max, 77–78

Bridge

Akashi-Kaikyo, 29, 63–64, 92, 337, 397,
407, 455–456, 459, 468

Alexander Hamilton, 24

arch, 19, 25, 51, 92, 111–112, 168, 176–
178, 203, 270, 323, 372, 442, 445–
448, 477, 498, 553–555, 579, 585,
609

bascule, 288, 460, 467

Bayonne, 19, 22, 27

Brooklyn, 18–20, 24–25, 28–29, 35, 49,
54, 58, 61, 82, 110–112, 125, 166,
171, 173, 226, 228, 260, 337, 397,
407, 409, 454, 458, 465, 469, 489,
493

cable stayed, 166, 230, 241

cable-supported, 455–459, 468, 494, 496,
579

Cincinnati-Covington, 48, 52, 166, 454

concrete, 91–92, 130–133, 553–555. *See*
also Concrete

Cypress Avenue viaduct (Rte. I-880), 120–
122, 188, 197, 212–214, 229–230,
304

Danube (at Budapest), 49, 52

Delaware canal, 167–168

extrados, 457–459

Firth of Forth, 54

George Washington, 19–20, 27–31, 63,
144, 166, 337, 384, 411, 496, 569

Goethals, 18, 92, 93

Golden Gate, 27, 29, 31, 35, 66, 227–228,
379, 381

Great Belt, 30–31, 63, 66, 282, 337

Hakkucho, 459

Hell Gate, 19, 21, 27, 92

Henry Hudson, 19, 23, 92

High Bridge, 323

Hoan, 193, 438

integral abutment, 274, 639

iron, 379

Kurushima, 397, 406–407

lift, 24, 285–287, 406, 460, 554

Macomb's Dam, 15, 406

Manhattan, 18–20, 25, 49, 54, 56, 60–62,
207, 265, 408, 490

Mianus, 57, 107, 188, 212–215, 274, 301,
438

Mid-Hudson rail, 53–54

Millennium, 103–104, 109, 227, 469

masonry, 119, 442, 448, 450, 498, 553,
579, 611, 630

movable, 18, 130–133, 142, 203, 285–
289, 308, 335, 384, 435, 453, 459–
460, 470–472, 489, 554, 635

multi-span, 454

New River Gorge, 477

Passerelle de Solferino, 103–104, 109,
227, 469

Point Pleasant, *see* Bridge, Silver Bridge

Pont d'Aquitaine, 302, 305, 397, 458

Pont de Tancarville, 111, 263, 302, 396,
455, 458

Pont du Diable, 103

Pont du Gard, 323

Pont Neuf, 176–178, 281

Ponte Rotto, 51

pedestrian, 18, 53–54, 63–64, 69, 92, 123,
153, 227–228, 234, 238, 269–270,
272, 323, 453, 553–555, 590

prestressed, 27, 190, 203–204, 245–246,
263, 267–269, 301, 335, 339, 377,
459–460, 494, 553–554, 577, 609,
611–612

Quebec, 27, 101, 103, 108, 126, 185, 579

Queensboro, 19, 21, 27, 56, 61, 106, 126,
496

rail, 18–19, 25, 50, 53–54, 91–92, 94,
143, 160–161, 174, 234, 247, 260,
262, 311, 321, 323, 337, 348, 362–
365, 406, 408, 437, 448, 453–454,
471, 474, 477, 553–555, 564, 590,
592, 610–611

Retractable, *see* Bridge, movable

Rion-Antirion, 241–242

- Risorgimento, 203
 Schoharie Creek, 57, 107, 159, 165, 228–229
 San Francisco–Oakland Bay, 62–66, 68, 95, 166, 211, 217, 219, 229–230, 444
 segmental, 269, 554, 588
 signature, 63–64, 166, 430
 Silver Bridge, 105–109, 123–124, 213–214, 230, 247, 274, 301–303, 438, 454
 Smithfield, 27, 92, 166, 247
 steel, 25, 91–93, 106–107, 180, 198, 203, 207, 232, 377, 553–555. *See also* Steel
 suspension, 13–19, 29–31, 45, 49, 54–59, 68, 82, 92, 105–106, 110–112, 126, 198–201, 233, 245, 247, 260, 263, 274–275, 302, 364–365, 379, 396–398, 438, 453–459, 489–490, 495–498, 510, 533–555, 584–585
 swing, 374–375, 406, 460, 554
 Sydney Harbor, 380
 Tacoma Narrows, 101, 103, 108, 126, 153, 185, 226, 233, 468
 Tappan Zee, 101–102, 174
 Tatara, 63, 65, 441, 455
 Third Avenue, 374
 Throg's Neck, 19, 23, 144
 truss, 19, 29, 54, 63, 92, 105, 110–112, 126, 196–198, 207, 239, 301, 345, 372, 443–444, 454, 473, 489–496, 554, 582, 586, 609
 Tsing Ma, 30–31, 281
 vehicular, 18–19, 28, 91–94, 102, 160–162, 175, 189–191, 207, 218–222, 236–237, 262–264, 276, 323, 362–363, 378, 471, 477, 549, 576–577
 Verrazano, 19, 27–29, 144
 Viaduct de Millau, 63–64, 69, 103, 423
 Washington, 19, 24, 445
 West Side Highway, 172
 Whitestone, 19, 23, 144, 233, 468
 Williamsburg, 19–20, 54–63, 95, 107, 110, 185, 261, 276, 364–365, 393, 396, 454–455, 490, 493, 495
 Willis Avenue, 374, 406
 Bridge Management in Europe (BRIME), 96, 99, 101, 167, 226, 321, 326, 335, 349, 362, 383, 448, 560, 612–613
 Brunel, Isambard Kingdom, 15, 18, 126
 Brunel, Sir Marc Isambard, 17, 126
 Bruneleschi, Fillippo, 6
- C**
- Caesar, Caius Julius, 34, 37, 39–41, 87
 California Department of Transportation (Caltrans), 328, 434, 463, 592–593, 616
 Cladding, 257–258, 470–472, 630
 Clinton, William J., 97
 Comte, Auguste, 13
 Concrete
 alkali-silica reaction (ASR), 260, 496
 bent, *see* Concrete, pier
 construction, 245, 250, 260, 267, 427
 deck, 56, 179, 202–206, 224–225, 232, 252–258, 278, 302–305, 358–359, 363–364, 452, 496
 degradation, 260, 364–365, 369, 621–626
 delamination, *see* Concrete, spalling
 design, 15, 27, 190, 194, 241–244, 577, 588–592
 deterioration, *see* Concrete, degradation
 failure, 124, 195, 241, 246, 248, 251, 267, 272, 304, 375
 overlay, 248, 278
 pavement, *see* Concrete, overlay
 pier, 230, 234, 395
 prestressing, 245, 267, 459
 post-tensioned, 204
 quality control & quality assurance, *see* Quality Assurance & Quality Control
 shell, 124
 spalling, 240, 248, 250–260, 440, 471, 633
 Condorcet, Antoine Caritat, marquis de, 44, 48
 Cornell, C. Allin, 64, 80–81, 293, 332–333, 415, 536
 Corrosion
 of piles, 265
 of reinforcement, 260, 264–265, 365
 of steel bridges, 55–56, 274, 283, 374, 438, 471
 of wires, 265, 344, 456
- D**
- Data, 60, 80–84, 154
 acquisition, 95, 285
 data base and database, 16, 69–70, 100, 136–138, 333, 340–345, 557
 interpretation of, 349, 365–367
 management and maintenance of, 155–158, 186, 306, 311–320, 565, 575
 processing, 72, 79

- Data (*continued*)
 quantitative, 69, 79, 344
 reduction, 176–179
 sources of, 366–367
 span-specific, 345
 uncorrelated, 186, 280
- Deflections, 589
- Descartes, René, 6, 10–11, 34, 74–76, 103, 284, 291, 312, 326, 412, 507–509
- Design
 AASHTO specifications, 80, 101, 188–194, 202–207, 250, 270, 453–455, 460, 498
 AREMA specifications
 performance-based, 134, 417, 427
 loads, *see* Loads
- Duplication of effort, 159–160, 307–327, 334, 427, 485, 506
 redundancy control, 306
- Discount rate, 165
- Drucker, Peter, 78, 82, 84, 86, 95, 158–159, 318, 419, 423
- Du Pont, Eleuthere Irenée, 40
- E**
- Eads, James Buchanan, 17–18
 Edison, Thomas, A., 39, 47, 82
 Eiffel, Gustave, 8, 14–15, 25–26, 28, 35, 50, 140, 162, 171
 Eiffel Tower, 28, 50, 52, 63
 Einstein, Albert, xii, 76–78, 80, 174, 317
 Estaing, Valéry Giscard d', 44
 Euler, Leonard, 78, 91, 578
 Eurocode, 101
 Evaluation, *see* Assessments; Nondestructive testing and evaluation (NDT&E)
- F**
- Failure, 103–127
 administrative, 139
 assessment, 473
 bearing, 219, 444, 464
 business, 270
 catastrophic and global, 94, 108, 154, 375–376, 593–594
 communication, 153–156
 connection, 212–214, 230, 248, 274, 443
 construction, 109, 124
 deck, 196–196
 design, 124
 joint, 215–216, 394
 maintenance, 376
 management, 86, 101–102, 156, 193, 212, 285
 material, 107, 193–195, 244–247
 mechanical, 182, 470
 modes and mechanisms, 134, 189, 300–302, 305, 369, 455, 460, 549, 561, 565, 582, 582, 622–623
 partial and near, 109, 186
 penalties, 375, 596, 604
 potential, 437
 probability and likelihood of, 291–308, 314, 347, 361, 535, 539–548, 596
 progressive, 373
 restrainer, 230
 structural, 108, 143, 182, 187, 192–193
 symptoms, 445
 wearing surface, 279
 wire, 456–458
- Fatigue, 104, 107, 130–133, 182, 192, 245–247, 358, 379, 394, 438, 486–502, 536, 539
 corrosion, 263, 438, 460
 of concrete, 124, 203–206, 248–251, 278–280
 of steel, 206–207, 211, 215–216, 225, 245–248, 262–264, 365, 451–454
 shear, 195
- Federal Emergency Management Agency (FEMA), 240, 295, 463
- Federal Highway Administration (FHWA), 97–101, 107, 162, 166, 181, 183
 approval by, 141
 audits, 155
 inspection requirements, 144, 160, 185, 188, 213, 230–232, 260–263, 277, 317, 321–325, 338–344, 359, 365, 371, 378, 382, 393, 401, 413–417, 429–433, 436–439, 448, 458, 487, 496–499, 550–555, 564–567, 599, 606–609, 615–617, 621, 626–630, 643–646. *See also* National Bridge Inspection Standards (NBIS); Inspection and evaluation
- Feynman, Richard, 78, 120, 154, 291, 326, 348, 431, 506
- Finley, James, 12, 17, 45
- Fracture, 94, 107, 112, 244, 247–248, 259–260, 303, 306, 339, 394, 576–577, 591
 -critical, 107, 130, 132, 144, 199, 211, 213, 245–247, 268, 274, 284, 287,

- 300–304, 341, 375, 396, 436–438,
446, 549, 552, 630, 633
-toughness, 539
Franklin, Benjamin, 36–37, 42–43
Franklin Square truss, 489, 493
Freyssinet, Eugene, 16, 27
 Freyssinet Company, 69
Fuzziness, 79–81, 291–293, 308, 313, 336,
 362, 369, 418, 473, 540, 548, 637
- G**
- Galbraith, John Kenneth, 72, 74, 78, 84
Galilei, Galileo, 6, 34, 74
Gödel, Kurt, 76, 188
- H**
- Hausmann, Georges, Baron, 64
Hazards, 340–342
 flags, 530–637
Heisenberg, Werner, 76
Hegel, Friedrich, 16, 18, 74–75
Hennebique, Francois, 14
Holmes, Oliver Wendell, 300, 533–535
Holmes, Oliver Wendell, Jr., 42, 533–535
Hooke, Robert, 7, 192, 578
Hoover, Herbert, 38
Hudson, W. R., xii, 100, 158, 163, 294, 312,
 316–319, 369, 372, 374, 382–383, 408,
 412–413, 415, 421, 441
Hughes, Howard, 40
- I**
- Ignorance, 78–81, 120–122, 152–156, 186,
 287, 308, 313, 449, 539
 factors, 189
 in decision making, 418
 of assessed conditions, 360
Inspection and evaluation, 55–58, 82, 100–
 101, 107, 120–122, 129–137, 156–160,
 429–485. *See also* Nondestructive
 testing and evaluation (NDT&E);
 Structural condition
 biennial, 57, 176, 348
 courses, 144
 emergency, 150
 hands-on, 117–118
 in-depth, 149, 177
 maintenance, 379
 of special emphasis details, 443
 optimization of, *see* Optimization
- procedures, *see* Inventory, National Bridge
 Inventory; National Bridge Inspection
 Standards (NBIS)
records, 387
regular, 335, 342
reliability and quality of, *see* Reliability,
 of inspections
special, 335
tasks, 343–346, 364–365
visual, 115, 160, 175, 343–344
vulnerability of, *see* Vulnerability, of
 inspections
- Intermodal Surface Transportation Efficiency
 Act (ISTEA), 161–162, 411, 549
International Association for Bridge and
 Structural Engineering (IABSE), 100,
 294, 348, 456
International Association for Bridge
 Maintenance and Safety (IABMAS),
 100
Inventory, 135–137, 175–176, 216, 231,
 251–252, 307, 312–333, 338–343, 362–
 363, 366, 384, 393, 464
 deficit, 327
 input, 413, 483, 541
 National Bridge Inventory (NBI), 98, 322,
 337–339, 347–348, 371–376, 438,
 460, 549–555, 590, 597, 606, 609–
 615, 622–627, 630, 641
 update, 448–455, 463
- J**
- Jefferson, Thomas, 37–38, 46
- K**
- Kant, Immanuel, 74
Karnakis, Eda, 13, 17, 108, 126, 244
Kierkegaard, Sören, 76–77, 152, 361
Kline, Morris, 7, 74–76, 412
- L**
- Laplace, Pierre-Simon, Marquis de, 44, 74–
 75, 79, 139, 603
Lavoisier, Antoine Laurent, 34, 40
Leibnitz, Gottfried Wilhelm, 6, 412, 509
Lesseps, Ferdinand de, 18, 35
Leonhardt, Fritz, 188
Lindenthal, Gustav, 15, 18–19, 27–28, 54,
 92
Load, 80, 93, 104, 123, 127, 130–136, 218–
 244, 246, 294, 350, 410

Load (*continued*)
 allowable, 189
 amplification, 195, 222–223
 buckling, 441–447. *See also* Analysis,
 stability
 combined, 195, 206, 243–244, 295, 300,
 575–577, 575–593
 construction, 270
 cycles, 248
 dead, 218–221, 278, 334, 406, 471
 design (AASHTO), 107, 189–192, 471,
 590
 dynamic, 4, 184, 195, 221
 extreme events, 228–243, 462
 factor, 188, 192, 225, 292, 544–549, 561–
 563, 590–592
 fire, 237–241
 impact, 234–237
 lane, 226–228
 live, 112–114, 198–199, 202–203, 221–
 228, 248, 278, 339, 439, 453, 553,
 588–590
 path, 451
 pedestrian, 236–238, 468, 477
 posting, 328, 331, 362, 552
 proof, 126, 489
 quasi-static, 222
 rating, 111, 160, 225, 301, 322, 325, 331–
 335, 338, 344, 361–367, 395, 417,
 484, 551
 rating (AASHTO), 626–630
 rating (BRIME), 612–613
 redistribution, 109, 119, 159, 192, 214,
 294, 299–304, 395, 438, 600
 release, 117–118, 197
 repetitive, 247
 sabotage, 241–243
 seismic, 195, 214, 229–233, 307
 service, 191, 247, 334
 static, 4, 471
 testing, 486–496
 train, 94
 ultimate, 189, 192, 562
 vehicular, 94–95, 206, 222
 wind, 233, 406, 468

M

Machiavelli, Niccolo, 6, 34
 Maintenance (structural), 54–63, 82, 130–
 136
 bridge-specific, 406, 459, 472

cost estimates, 99, 147, 158, 165–171,
 264, 326–331, 353, 369, 372, 383,
 400–406, 419
 cost-effective, 298, 386–392, 404, 498
 deferred, 144, 181–184, 631
 definitions, 372–375
 demand, 150, 168, 353
 ineffective, 123, 497
 maintainability, 158, 273–276, 395–396,
 638–639
 management system, *see* System,
 maintenance management (MMSS)
 manual (AASHTO), 101, 549, 643–644
 manual (NYC DOT), 384–386
 needs, *see* Needs
 performance of, *see* Performance,
 maintenance
 prescribed, 382–384
 preventive (PM), 168, 278, 373–379
 rating (FHWA), 608
 records, 472, 484, 621
 reliability-centered, 374
 tasks, 162, 263, 275, 285, 319, 325, 369,
 384, 426–435, 470, 639
 vulnerability of, 278–282, 286
 zero, 382–383
 Michelangelo Buonarroti, 6, 8
 Moisseiff, Leon, 15, 18–19, 31, 126
 Moses, Robert, 64–65, 70, 82
 Murphy's law, 120, 282, 290, 308, 549

N

National Bridge Inspection Standards
 (NBIS), 316, 321, 323, 325, 327, 334–
 338, 341, 345–348, 359, 362, 395,
 436–439, 448–452, 460, 472, 484–485,
 550–552, 606, 611, 621, 645
 National Cooperative Highway Research
 Program (NCHRP), xii
 Reports, *see* References section
 Synthesis, *see* References section
 Navier, Claude-Louis-Marie-Henri, 13, 126,
 244, 578
 Needs, 368–422
 capital improvements, 377
 economic assessments, 398
 hazard mitigation, 374
 integration, 377
 maintenance and repair, Section 11.4,
 368–398
 quality and quantity of service, 371

- quantification, 369
 - Networks and projects, 62, 72, 87, 94–99, 128, 135–136, 139, 144, 154–167, 175–185, 231, 313–318, 551–552
 - Assessments, *see* Assessments, of networks and projects
 - Inventory, *see* Inventory
 - New York City
 - bridges of, 15, 17–24, 27–29, 37, 54–64, 323
 - New York State Department of Transportation (NYS DOT), 147–148, 175, 179, 296–298, 313, 324–327, 334
 - bridge management system, *see* System, bridge management (BMS)
 - condition rating, *see* Structural condition inspection, *see* Inspection
 - vulnerabilities, *see* Vulnerability
 - Newton, Isaac, 6–7, 34, 74, 76, 103, 108, 192, 578
 - Nondestructive testing and evaluation (NDT&E), 487–502
- O**
- Occupational Safety and Health
 - Administration (OSHA), 270, 286, 425–427, 473–476
 - Octavian Augustus, 41
 - Optimization, 91–102, 128, 147, 181–183, 279, 284, 293, 327, 413–420, 485, 512, 541–545
 - algorithms, 183, 369, 557–559, 599–605
 - life-cycle, 411
 - multiobjective, 368
 - of failure modes, 299
 - of inspection, 182, 283
 - of maintenance, 280, 389
 - operational research, 418
 - prioritization, 96–100, 145, 232, 292, 307, 315, 338–339, 345–348, 361–371, 419, 593–599
 - Organization for Economic Cooperation and Development (OECD), xi, 95–96, 312–315, 321, 359, 368, 376, 383, 558
 - Otis, Elisha Graves, 27
- P**
- Paine, Thomas, 37, 45, 76, 145
 - Paint and painting, 29, 60–61, 130–133, 161–162, 168–170, 179–180, 246, 263–264, 273–274, 325, 369, 379–393, 427, 434, 471, 479
 - Paris
 - city of, 10, 12–13, 16, 25–26, 50, 64, 69, 71, 126, 162, 176
 - judgment of, 32–34
 - Pascal, Blaise, 11, 75–76, 507
 - Peer review, 135–137, 153, 216, 426–432, 485
 - Pennsylvania Department of Transportation (PennDOT), 101, 357, 359, 363, 426, 480–481, 557, 621
 - Performance
 - curve, 408
 - engineering, 83, 203
 - evaluation, 184
 - indicators, parameters, and standards, 134–136, 154, 184, 213, 368–371, 412–413, 417–421, 434
 - level, 352
 - maintenance, 280, 317, 322, 343–344, 378–383, 387–392, 427–435, 477, 644–645
 - management, 73, 79, 153–155, 193, 212, 229, 428, 434
 - material, 244, 260–267, 378
 - network and system, 301–308, 317, 321, 410, 421, 428
 - pavement, 358
 - personnel and task, 153–154, 285, 308, 378, 384, 425–427, 434, 448–449, 453–455
 - software, 207
 - structural, 63, 80–82, 96, 108–113, 120, 127–128, 139, 182–183, 190, 197, 201, 206–207, 211–212, 215–216, 232, 245, 274–276, 285, 293–308, 336, 339, 369–372, 396, 425, 429, 443–446
 - Peronnet, Jean Rodolphe, 14, 16, 134, 313
 - Petroski, Henri, 16, 92, 103, 108, 120, 126, 533, 611
 - Plato, 6, 44, 63, 66, 73
 - Plutarch, 34, 41, 87
 - Privatization, 140, 160, 185, 410, 567–568
 - Process and product, 3, 25, 68, 72, 82–87, 96, 99, 103–108, 120–138, 370–372.
 - See also* Reliability; Quality Assurance & Quality Control; Vulnerability, of product and process

Procurement, 433
 contracting, 570–573
 bidding, 570–571
 letting, 569–570

Q

Quality Assurance & Quality Control, 136,
 426–427, 484, 642

R

Randomness, 76, 78–81, 122, 192, 539–546,
 602
 of assessed conditions, 148, 342
 of assessments, 283, 361
 of hazards, 375
 of loads, 221, 586
 of events, 231, 273, 307, 334, 339, 462,
 545
 of sampling, 643
 of uncertain variables, 293–295, 299, 536,
 603, 620–622

Reliability, 3, 101, 109, 314, 332–333
 Bayesian, 75, 79–81
 as function of redundancy, 160, 506, 561–
 564
 index, 189, 347, 617
 of inspections, 371, 429, 479–485, 503
 lifetime, 622
 of models, 259
 of networks, 306
 of product and process, 123, 307, 427
 of structures, 120, 159, 291–308, 415–
 418, 436–545
 profile, 352
 quantified, 382
 state, 361
 targeted, 604

Repair, 393
 emergency, *see* Repair, temporary
 concrete, 639
 repairability, 395
 temporary, 451–452

Resources, 128, 143, 152, 174, 326–327
 allocation of, 350, 360, 369, 415–418, 425
 demand for, 136
 engineering, 139, 483
 financial, 45, 99–100
 human, 4, 41, 84, 87
 management of, 233, 297, 313, 317, 432–
 435, 557, 565–570, 573, 644–645
 natural, 41, 87

supply of, 153

Response, 292, 326–337
 capability, 343–348, 448
 emergency, 144, 152, 228–229, 315, 378,
 429, 434, 462–463, 472, 571
 engineering, 101, 189, 229
 federal, 155
 management, 185, 383, 414, 498, 570,
 614, 631–633
 structural, 137, 175, 196, 203, 231–233,
 245, 284, 294, 300–301, 317, 439,
 459, 375, 465–469, 486–498, 577–
 579, 587

Roebbling
 high-strength wire company, 18
 John, 14, 16, 18–19, 24, 36, 48–49, 63,
 110–111, 125, 233, 454
 Emily, 25
 Washington, 16, 24, 36, 67, 226

Roosevelt, Franklin D., 82–83

Russell, Bertrand, 78, 540

S

Salvadori, Mario, 81, 86, 109, 121, 270,
 311, 453, 578

Santayana, George, 80, 103, 308, 315

Schlaich, Jorg, 58–59, 203, 205, 456

Seismic
 design, 592–593
 prioritization, 599

Servan-Schreiber, Jean-Jacques, 72, 74, 78

Slater, Rodney, 98

Socrates, 6, 63, 65–66, 73

Special emphasis details, 439

Steel
 columns, 230, 234–235, 240, 274–275,
 442, 471
 corrosion of, *see* Corrosion
 corrosion-resistant, 256, 265–266, 639
 design, 190, 203, 207, 241, 244–247,
 577–593
 details, 596. *See also* Fatigue
 fatigue of, *see* Fatigue
 fracture of, *see* Fracture
 grating, 179, 203, 206–209, 275, 279,
 406, 460
 high-strength, 247, 263
 painting of, *see* Painting
 reinforcement, 250
 residual stresses, 245
 welding, 284

- wires, 455
- Steinman, David B., 15–16, 18–19, 27, 92, 455
- Steinman, Boynton, Gronquist, and Birdsall, 59
- Stephenson
 - George, 7, 47
 - Robert, 15, 47
- Strategies and tactics, 312
 - critical path method (CPM), 307
 - Federal Infrastructure Strategy Program, 574
 - inspection, 332, 283
 - investment, 420
 - maintenance, 168–170, 181–183, 372–383, 472
 - management, 144, 237, 293, 414–415, 419–420, 600
 - triage, 145, 152, 296–297, 342, 368, 463
- Strauss, Joseph, 27, 31
- Structure, 129, 311–315
 - ancient, 48
 - components, elements, and members, 323
 - condition, *see* Structural condition
 - continuous and discontinuous, 216
 - ductile, 109, 301–304
 - empirical, 15
 - hierarchical, 637
 - logical, logistical, 314, 545
 - matrix, 134
 - model, 137, 156, 189–208, 333
 - new and existing, 91, 166–168, 174–179, 229–230, 357, 377–384, 396, 453, 508, 544
 - organizational, 96, 134, 144, 154, 193, 301, 312, 567
 - performance of, *see* Performance, structural
 - redundant and nonredundant, 112, 159, 248, 300–307, 396, 442, 561–564, 582
 - relational, 427, 567
 - response of, *see* Response, structural
 - smart, 498
 - special, 158
 - unique, 92, 139, 335, 485
 - unstable, 193
- Structural condition, 336–367
 - bridge ratings, 614–618
 - condition forecasting, 345, 350–352, 353–357, 358–362, 637
 - evaluations, Section 10.4, 343–361
 - element ratings, 147–152, 175–180, 284, 17, 295–299, 322, 334, 341, 611–614
 - potential hazards, 340–341
 - rating systems, *see* System, of assessment, evaluation, ranking, rating
 - serviceability appraisal, 321–336
 - state, 381–382
 - sufficiency rating, 149–150, 175, 307, 327, 336–367, 371, 610–616
 - vulnerability assessment, Section 10.2, 338–339, 596
- Superstructure, 322. *See also* Concrete; Steel concrete, 324
 - steel, 324
 - typical, 191, 325
- System, 11, 96, 129, 299–307, 311–319
 - analysis, 154, 158, 313–319
 - asset management, 414, 419–420, 555–556
 - bridge management (BMS), xii, 95, 101, 186, 504, 551–552, 557–561
 - data acquisition (DAS), 367
 - data(base) management, 306, 367, 541, 564–567, 482, 564–566, 575
 - decision support, 153, 213, 367
 - expert, 70, 637, 284, 345, 367, 414, 473, 503, 619–620, 637
 - formalized, 86, 193
 - global position (GPS), 489
 - highway management, 95, 134, 181, 307, 420, 554–555
 - Highway Performance Monitoring (HPMS), 317
 - Highway Structure Information (HSIS), 416
 - identification, 284–285, 332, 602
 - information management (MISS), 186–187, 504
 - infrastructure, 84, 91, 101, 141, 143, 150, 549–550, 569, 573
 - intelligent transportation (ITS), 416, 503
 - knowledge-based, 66, 125, 186
 - logical, 311
 - maintenance management (MMSS), 95, 100–101, 183, 372, 383, 434, 643–644
 - management, 95, 158, 419, 599–602
 - mechanical, 91
 - National Highway (NHS), 432
 - National Incident Management (NIMS), 242

System (*continued*)

National Transportation Performance
Monitoring (NTPMS), 605
of assessment, evaluation, ranking, rating,
147, 175, 325–335, 337–367, 393,
606–618
parallel and series, 129, 299–312, 347,
369, 561–562
project management, 425
protection, 285, 463
structural, 129, 134, 178, 190, 196, 202–
203, 213, 299–302, 371, 561–564,
585–593, 626–629
supply-demand (SDS), 410
warning, 229, 237

T

Telford, Thomas, 14
Tocqueville, Alexis de, 8, 10–12, 14, 79,
159, 315
Top-down and ground-up, 11, 82, 87, 95,
135–137, 154–155, 186, 343, 347, 415,
564
Toll, 18, 28–31, 57, 63, 185, 337, 410–414,
432–435, 472, 485, 506, 568–569

U

Uncertainty, 3, 74–81, 546. *See also*
Analysis, probabilistic; Fuzziness;
Ignorance; Randomness; Vagueness
aleatory, 540
definition of, 539–540
epistemic, 540
in decision making, 603
of assessments, 282–284, 292–293, 333,
352
of design loads, 591–594
of life cycle cost estimates, 600
probabilistic, 536
statistical, 536

V

Vagueness, 73, 78–79, 81, 84, 122, 124,
189, 274, 540

of assessments, 301, 327, 343, 360–361,
398
of expert opinions, 539
of maintenance, 284, 372, 434
of terminology, 189, 301, 321, 372, 428,
438, 453, 473, 481

Valéry, Paul, 14, 79, 103, 291
Value engineering, 165–166, 216, 426, 432
Vauban, Sébastien Le Prestre, 16, 42, 165
Veneer, *see* Cladding
Vinci, Leonardo da, 6, 79, 108, 121, 290
Vulnerability
according to O. W. Holmes, 534
assessment of, 367, 375
cost of, 600
models of, 366
NYS DOT, 339, 595
of analysis, 144, 157, 187–285
of automated decision support, 419
of BMS, 186, 313
of connections and discontinuities, 111,
120, 127–137, 155–160, 208–216,
274, 307, 449, 453, 498, 594
of construction, 101, 120, 124, 130–138,
244–273
of design, 187–273
of economic assessments, 401, 410
of emergency management, 571–572
of eye-bars, 107
of inspections, 282–284
of maintenance, 278–282, 392
of management, 139–186, 392
of operations, 285–286
of product and process, 128–290
rating, 322, 331
seismic, 593–599
structural, 338–340
to tort liability, 428
Voltaire (Francois-Marie Arouet), 7, 9
Von Neumann J. (and O. Morgenstern), 64,
78–79, 91, 415–418

W

Waddell, J. A. L., 63, 92, 165, 273–274,
277, 379, 393, 550–551