

Subject Index

A

- ABAQUS program, 246–249
- A* derivation, 14–17
- Alloys
 - chemical composition, 239
 - surface crack testing of cylindrical rods, 383–388
 - threshold testing, 305–306
- Almond-shaped crack
 - bending loading coefficients, 375
 - stress-intensity factor coefficient, 366, 368–372
 - tension loading coefficients, 374
- Alternating-current (A-C) field measurement
 - schematic, 355–356
 - tubular threaded connections, 348–363
- Alternating-current (A-C) potential drop (ACPD)
 - crack initiation and growth measurement, 242–246
 - test specimen and apparatus, 238–242
 - thermal fatigue histories, 246–249
 - thermal fatigue testing, 237–258
 - weldment surface crack analysis, 403–404
- Aluminum alloys
 - fractographic analysis, 340, 342–344
 - subcritical surface flaw growth, 334–336
 - surface flaw analysis, 216–236
- Anisotropic alloys, 237–238
- Antisymmetric loading, 13–14
- Aspect ratio, 360–361
- ASTM Standards
 - A 572, 295
 - A 710, 154
 - E 399–81, 291
- ASTM Test Methods
 - E 1152, 325
 - E 647–86A, 304

Asymptotic technique

- eigenfunction expansion, 66–67
 - HRR dominance in tensile-loaded surface cracks, 23–24
- Average crack growth rate, 256–258

B

- Beach marks, 383, 385
- Bending
 - almond-shaped cracks, 375
 - notched bar almond-shaped cracks, 380
 - notched bar sickle-shaped cracks, 382
 - sickle-shaped cracks, 377
 - uncracked notched bar, 378
- Block loading sequences
 - crack growth retardation, 265–266
 - surface flaw geometries, 262–264
- Boundary correction factors, 41–46
- Boundary-layer effect
 - finite-element models and methods, 37–40
 - stress-intensity factors, 94–96

C

- Center of rotation, 168–170
- Charpy-V notch testing
 - crack-tip opening displacement values, 154–155
 - impact toughness, 142–150
- Circumferentially cracked pipe, 21–22
- Closure loads
 - effective stress-intensity factors, 272–277
 - surface flaw geometry, 268–272
- Compact-type (CT) specimens
 - fatigue crack growth rates, 278–279
 - subcritical surface flaw growth, 333–346
 - surface crack growth computations, 287–302
 - surface flaw analysis, 215–236
- Complementary metal-oxide semiconductor (CMOS) switches, 244–246
- Complex load, corner crack stress-intensity factors, 53–56

Composite laminates
 near-surface layer failure, 186–189
 properties, 210–211
 surface cracks, 177–193
 Condensation technique, stress-intensity analysis, 69–70
 Constraint parameter
 crack front, 321–324
 internal pressure and thermal shock, 323, 325
 three-dimensional crack bodies, 323–324
 Continuum analysis, 21–22
 Convergence, 82–83
 Coordinate system
 fracture analysis, 64–66
 in-plane displacement measurement in PVC pipe, 137–138
 Corner crack
 schematic, 49–50
 stress-intensity factors, 49–61
 two-degree-of-freedom, 50–51
 Corner singularities, 13–14
 Correction factors
 stress-intensity solutions, 226–227
 surface flaws, 180, 185–186
 tubular threaded connections, 359–360
 Crack aspect ratio, 265–268
 Crack border-free surface intersection effects, 99–108
 Crack closure/opening loads, 268–273
 Crack closure threshold testing, 303–314
 Crack geometry, 383–388
 Crack growth
 crack-tip opening displacement values, 162–163
 dC/dN calculation, 219–220
 predictions, 279–285, 373–383
 surface crack testing of cylindrical rods, 383–388
 thermal fatigue testing, 237–258, 242–246
 Crack half length calculation, 288–290
 Crack initiation, 237–258
 Crack-mouth opening displacement (CMOD)
 load history and closure, 305–306
 surface flaw analysis, 112, 117–120
 Crack shape
 almond and sickle-shaped, 365–366
 crack front constraint variation, 323–324
 fatigue loading, 319–323
 prediction, 373–383
 stress-intensity factors, 40–46
 Crack size, 40–46

Crack-tip-opening angle (CTOA), 3–4, 152–176
 Crack-tip opening displacement (COD)
 effective stress-intensity factors, 272–277
 measurement, 3–4, 152–176
 surface flaw geometries, 264–265
 testing parameters, 298–302
 values, 162–163
 Critical conditions, failure assessment, 316–317
 Curvilinear coordinates, 64–66
 Cylindrical bars, surface crack growth, 365–388

D

Damage size measurements, 198–200
 Damage size predictions, 199–203
 Delamination growth, 186–189
 Depley tests, filament wound cases, 198
 Depth crack growth rate (da/dN), 231–232
 Dimensionless displacement solution, 68–69
 Dimensionless stress-intensity factors, 73–74
 Direct current (D-C) potential drop, 243–244
 Domain integrals, 14–17
 Double-beam illumination technique, 137–139
 Double-edge wedge specimen, 247–248
 Double-exposure holography, 138–139
 Dynamic loading, 142–150

E

Edge stress-intensity factor, 86–96
 Effective stress distribution, 123, 125, 127
 Eigenfunction expansion, 66–69
 Eigenvalues
 algorithm for linear-elastic fracture mechanics, 103
 in-plane displacement measurement, 133–134
 least-squares in-plane displacement measurement, 139
 semi-elliptical surface crack analysis, 84–85
 Elastic behavior
 crack-tip opening displacement, 152–176
 surface crack analysis, 9–30
 thermal fatigue testing, 246–253
 Elastic-plastic analysis
 crack-tip opening displacement values, 152–176

rapidly-loaded surface crack specimens,
142–150
surface crack review, 9–30
thermal fatigue testing, 246–253
Elastic stress fields, 77–97
Electro-discharge machining (EDM), 217–
218
Elliptical cracks
 composite laminates, 177–193
 orthotropic media, 178–180
 stress-intensity factors, in orthotropic
 medium, 190–193
 weight function, 353–354
Embedded elliptical crack geometry, 226–
227
Energy release rate, 367
Equilibrium equations, 65–66
Equivalent surface crack, 198–203
Exact solutions behavior, 78–81

F

Failure assessment
 calculation programs, 316–317
 valve casing, 317–319
Fatigue crack closure, 260–285
Fatigue crack growth
 aluminum plate surface flaw analysis,
 217–218
 computations and experiments, 3–4,
 287–302
 crack length, 338–339, 345–346
 failure assessment, 316
 maximum crack versus number of cycles,
 357–360
 plates, 215–236
 predictability, 278–285
 subcritical surface flaw growth, 333–339,
 346
 three-dimensional surface flaw
 geometries, 260–285
 threshold tests, 303–314
Fatigue crack initiation, 340–341
Fatigue loading, 319–323
Fatigue testing
 subcritical surface flaw growth, 334–336
 surface crack growth, 315–331
 tubular threaded connections, 348–363
 vinyl acetate monomer (VAM) joints,
 354–360
Fiber damage, 198–200
Filament-wound cases (FWC)
 damage size and prediction tests, 199–
 203
 deply tests, 198
 impact testing, 195–211
 residual strength tests, 197–198
Finite-element analysis
 convergence properties of p -version, 82–
 83
 correction factor, 185
 crack-tip opening displacement values,
 171–172
 HRR dominance in tensile-loaded
 surface cracks, 23–24
 plastically deformed surface flaw, 112–128
 p -version, 81–82
 slice synthesis, 225
 special computations, 290–291
 stress-intensity factors, 57–58
 surface flaw, 34–47, 112–128
 thermal fatigue testing, 237–258
 three-dimensional, 36–40, 122–128
Finite-element mesh
 stress-intensity factors, 70–71
 tubular threaded connections, 351–352
First-ligament failure, 204–205
Flat plate weight function, 399, 402, 410
Flow theory of plasticity, 19–20
Fluidized bed technique, 237–238
Fractography, 339–344
Fracture analysis
 dimensionless stress-intensity factors, 70–
 74
 eigenfunction expansion, 67–69
 finite-element mesh and special element,
 70
 governing equations in curvilinear
 coordinates, 64–66
 monotonic loading, 329–330
 rapidly loaded surface-cracked specimens,
 142–150
 stress-intensity factors in surface cracks,
 69–74
 three-dimensional bodies with surface
 crack, 63–76
Fracture mechanics
 composite laminates, 177–193
 linear-elastic, 10–14
 near-surface layer failure, 186–189
 optical stress analysis, 99–110
 prediction for rapidly-loaded surface
 crack specimens, 142–150
 semi-elliptical surface crack analysis, 77–
 97
 three-dimensional geometries, 260–285
Fracture resistance curves, 323–324
Free surface-crack border intersection, 134
Frozen stress algorithm, 102
Frozen stress analysis, 108–110

G

- Garwood J -integral equation, 326–328
- Geometry
 - failure assessment, 316
 - tubular threaded connections, 350–351
- Goursat-Kolosov stress functions, 131–134
- Graphite/epoxy composite
 - constituent properties, 210
 - impact damage, 194–211
 - physical properties, 210
 - strength predictions, 204–209

H

- Hertz's law, 195
- Holes, surface and corner cracks, 35
- Holographic interferometry, 130–140
- Homogenization assumption, 178–193
- Hooke's law, 65–66
- HRR dominance, 171–172
- Hybrid analogue-finite-element model, 360–361
- Hybrid stress analysis, 350–351
- Hydrostatic stress, 321–323

I

- "Ill-shaped" elements, 37–38
- Impact damage
 - equivalent surface crack, 198–203
 - filament-wound cases, 196–197
 - strength predictions, 208–209
 - surface crack analysis, 194–211
- Incompressibility, 86–94
- Indent notch, 333–346
- Induction heating, thermal fatigue crack, 237–258
- Initiation-fracture testing
 - smooth and indent notch, 340–341
 - subcritical surface flaw growth, 336–338
- In-plane displacements, 130–140
- Interferometric displacement gage (IDG), 305
- Inverse square-root singularity, 133–134
- Irwin stress-intensity solution, 223–225
- Isotropic alloys, thermal fatigue testing, 237–238

J

- J_{crit} value, 146–150
- J -integral
 - crack-tip opening displacement values, 152–176

- Garwood method, 326–328
- rapidly loaded surface-cracked specimens, 142–150
- Read method, 327
- surface crack growth computations, 20–22, 287–302
- surface flaw analysis, 112, 117–122
- J - R curve
 - geometry and instrumentation, 326
- J curve comparison, 329–331
- monotonic increasing load, 323–331
- J resistance curve, J - R curve comparison, 329–331

L

- Lamé coefficient, curvilinear coordinates, 65–66
- Laplace equations, 78–81
- Lead-before-break behavior, 318–319
- Least squares, in-plane displacement measurement, 134–137
- Ligament failure
 - composite laminate surface cracks, 177–178
 - surface cuts, 205–208
- Linear elastic fracture mechanics
 - algorithms, 100–103
 - nonsingular effect, 103–104
 - semi-elliptical surface crack analysis, 78
 - subcritical surface flaw growth, 333–346
 - surface crack growth computations, 10–14, 287–302
- Line-spring analysis, 17–21
- Load displacement curves, 156–157
- Loading history
 - CTOD and CTOA values, 172–176
 - surface crack growth and, 304–314
- Loading parameters, 316
- Load ratio, 333–346
- Local-global analysis, 63–76
- Locking effects, 82
- Love's solution, 201–202

M

- Magnification factors, 92–93
- Maximum strain criterion, 205
- Maxwell-Betti reciprocity theorem, 83–84
- Metallographic slicing, 157, 162
- Microcrack initiation, 254–257
- Microtopographic techniques, 157–161, 163–167
- Moiré interferometry
 - in-plane displacement measurement, 134–137

optical analysis, 110
 surface flaw analysis, 113–114
 Monotonic loading
 models and experiments, 2–3
 surface crack growth, 315–331
 Motor cases, impact damage analysis, 195–211
 M(T) crack specimens, 295–296

N

Near free surface effects, 30
 Near-surface layer failure, 186–189
 Near-threshold crack growth behavior, 303–314
 Near-tip problem geometry and notation, 100–101
 Newman-Raju solution
 crack-tip opening displacement values, 169–172
 fatigue crack growth rate prediction, 280–282
 stress-intensity analysis, 225–226
 Newman width correction factor, 226, 228
 Newton interferometry, 260–285
 Newton-Raphson minimization, 292–293
 Nodal-force method, 38–40
 Nondimensional stress-intensity factors, 54–61
 Nonsingular effect, linear elastic fracture mechanics, 103–104
 Notched rods, surface crack growth, 365–388
 Notches
 subcritical surface flaw growth, 333–346
 size, stress-intensity factors, 40–46
 Numerical differentiation, 117

O

Optical analysis
 free-surface effects on cracks, 99–110
 frozen stress analysis, 108–110
 plastically deformed surface flaw, 112–128
 Optical spatial filtering, 113–115
 Optimization, special computations, 291–295
 Orthotropic media
 elliptic cracks, 178–180
 stress-intensity factors, 190–193

P

Paris equations
 failure assessment, 316
 fatigue crack growth rate prediction, 282–284

surface flaw crack growth, 229
 tubular threaded connections, 357–358
 unnotched rods, 383–384
 weldment surface crack analysis, 408–411

Partially embedded ellipse, 230–231

Part-through cracks

 fracture behavior predictions, 146–148
 line-spring analysis, 17–21
 orthotropic media, 179–180

Phase-locked loop (PLL) system, 244–246

Plasticity, surface flaw analysis, 112–128

Plates

 dimensionless stress-intensity factors, 73
 surface and corner cracks, 35, 215–236

PMMA polymer surface crack growth geometries, 260–285

Poisson's ratio

 eigenvalues, 84–85
 magnification factor, 92
 semi-elliptical surface crack analysis, 78

Polynomial coefficients, 225–226

Potential drop technique, 243–244

Power-law deformation theory, 19–20

Power spectrum density function, 403–404

Pressure vessels, 287–302

p-version finite element method
 convergence properties, 82–83
 reliability, 96–97

R

Raju-Newman solution

 surface and depth crack growth rate curves, 232

 surface crack shape change, 234–235

Read *J*-integral equation, 327

Refined polariscop schematic, 109

Remaining-ligament strength criterion, 205

Residual tensile strength

 filament-wound cases, 197–198
 graphite/epoxy composite, 194–211

Root-mean-square relations, 52

S

Scanning electron microscopy, 334–346

Semicircular crack fronts, 25–29

Semicircular edge notch, 40–46

Semi-elliptical cracks

 composite laminates, 177–193
 convergence properties, 82–83
 eigenvalue determination, 84
 exact solutions behavior, 78–81
 finite-element mesh models, 90–96
 HRR dominance, 25–29

Semi-elliptical cracks—*continued*

- model problem, 84–90
 - numerical solutions, 77–97
 - p*-version of finite-element method, 81–82
 - stress-intensity factors, 41–46, 83–84
 - surface flaw shape characterization, 229–231
 - T-butt welded joints, 392–399
 - weight function stress-intensity factor, 354
 - welded joints, 390–412
- Sickle-shaped cracks
- bending loading, 377
 - stress-intensity factor coefficients, 366, 368–373
 - tension loading, 376
- Simplified models, surface crack analysis, 17–22
- Single-edge notch bend (SEB)
- deep cracked, 144–148
 - shallow cracked, 145–148
- Single-edge notched (SEN), 18–19
- Singular integral, finite-element hybrid (SIFEH), 12
- linear-elastic fracture mechanics, 11–13
- Slice synthesis technique
- corner crack stress-intensity factors, 56–59
 - finite-element model, 225
 - stress-intensity factors, 56–59
- Society of Experimental Stress Analysis
- consensus solution, 226–228
- Special element properties, finite-element mesh and, 70–71
- Specimen geometry
- surface flaw analysis, 113–114, 116
 - thermal fatigue testing, 238–239
- Specimen-to-structure correlations, 287–302
- Square-root singularity, 79–81
- Strength predictions, 208–209
- Stress analysis
- surface crack, 2
 - tubular threaded connections, 348–363
- Stress distribution, 349–353
- Stress gradients, 49–61
- Stress-intensity factor
- calculations, 52–53
 - circular crack, 180–181
 - closure-load data, 272–277
 - computations and experiments, 287–302
 - contour integral calculation, 83–84
 - corner cracks, 49–61
 - distribution, 107–108

edge cracks, 394–395

elliptic and semi-elliptic flaws, 178, 180, 182–183, 190–193

high-order special element, 69–70

infinite media, 180–183

in-plane displacement measurement, 130–140

loading parameter evaluation, 316–317

nondimensional, 54–59

notched and unnotched rods, 365–388

orthotropic medium, 190–193

plates, 215–236

semicircular edge notch, 40–46

subcritical surface flaw growth, 345–346

surface crack, 34–47

T-butt welded joints, 392–399

three-dimensional finite-element analysis, 36–38, 36–37

transversely isotropic media, 180, 184

threshold testing of crack closure and load, 303–314

tubular threaded connections, 348–363

weight-function calculation method, 365–368

weldment fatigue cracks, 390–412

Stress-intensity solutions

Irwin solution, 223–225

Newman-Raju solution, 225–226

surface flaw analysis, 223–226

Stress ratio (*R*)

crack closure behavior, 304–314

crack shape development under fatigue loading, 320–321

Stress state variation correction, 319–320

STRIPE program, 81–82

Subcritical growth, surface flaw, 333–346

Superalloys, thermal fatigue testing, 237–238

Surface crack growth

computational and experimental results, 295–302

elastic and elastic-plastic behavior, 9–30

failure assessment, 315–319

fatigue crack growth computations, 288–291

fracture analysis of three-dimensional bodies, 63–76

HRR dominance, 24–29

line-spring analysis, 17–21

monotonic increasing load, 315–331

optimization method, 291–295

plastic hinges, 21–22

Surface cuts, strength predictions, 205–208

Surface flaw, 112–128
 correction factors, 180, 185–186
 CT crack growth rate data, 231–232
 growth predictions, 232–235
 plates, 215–236
 shape and growth rate at depth (da/dN), 220–223
 subcritical growth, 333–346
 shape characterization, 229–231
 size and subcritical growth, 333–346
 three-dimensional geometries, 260–285
 threshold testing of crack closure and load, 303–314
 Surface layer failure, 186–189
 Surface stress distribution, 349–351

T

T-butt welded joint
 edge crack, 394–395
 semi-elliptical surface cracks, 392–399
 Tensile-loaded surface cracks, 22–29
 Tension loading
 almond-shaped cracks, 374
 notched bar almond-shaped cracks, 379
 notched bar sickle-shaped cracks, 381
 plastically deformed surface flaw, 112–128
 sickle-shaped cracks, 376
 surface cracks in cylindrical rods, 370–372
 uncracked notched bar, 378
 Thermal fatigue testing, 237–258
 Thick-shell isoparametric elements, 69–70
 Threaded connections, surface cracks, 348–363
 Three-dimensional crack problems
 computations and experiments, 287–302
 evaluation of, 37–40
 fracture analysis, 63–76
 geometries, 260–285
 singular integral formulations, 12
 stress-intensity factor, 36–37
 surface flaws, 12, 36–40, 112
 Threshold testing, fatigue crack growth, 303–314
 Through-thickness stress distribution, 352–353
 “Thumbail” cracks, 100–106
 Transition crack length, subcritical surface flaw growth, 333–346

Tri-axiality factor, crack front constraint variation, 323
 Tubular threaded connections, 348–363
 Turner's Engineering J approach, 146–147
 Two-part failure
 elliptic and semi-elliptic flaws, 178
 medium-depth flaws, 189

U

Unnotched rods, surface crack growth, 365–388

V

Valve casing failure assessment, 317–320
 Variable-amplitude stress history, 405–408
 Variable eigenvalue algorithm, 100
 Variable loading history, 390–412
 Vertex-edge intensity factor, 88–96
 Vertex intensity factor, 86–90
 Vinyl acetate monomer (VAM) joints, 354–360
 Virtual-crack-closure technique (VCCT), 38–40
 Virtual crack extension, 14–17
 Virtual grating schematic, 110
 Von Mises' stress, crack front constraint variation, 321–323

W

Weighted average stress range, 405–408
 Weight function
 corner crack, 49–52
 edge crack, 394–395, 397–398
 flat plate, 399, 402, 410
 notched and unnotched rods, 365–388
 semi-elliptical surface crack, 398–399
 stress-intensity factors, 58–59, 365–368
 tubular threaded connections, 348–363
 welded joints, 390–412
 Weld angle, stress-intensity factor, 400
 Weldments, surface fatigue cracks, 390–412
 Weld toe radius, stress-intensity factor, 401
 Westergaard approach, in-plane displacement measurement, 130–134
 Width correction, stress-intensity solutions, 226–228
 Wien bridge oscillator, thermal fatigue testing, 244–245