

Contents

Introduction	1
1 Elements of solid mechanics	5
1.1 Stress	5
1.1.1 Stress vector	5
1.1.2 Stress tensor	7
1.1.3 Equilibrium conditions	11
1.2 Deformation and strain	11
1.2.1 Strain tensor	11
1.2.2 Strain rate	14
1.3 Constitutive laws	15
1.3.1 Elasticity	15
1.3.2 Viscoelasticity	19
1.3.3 Plasticity	23
1.4 Energy principles	28
1.4.1 Energy balance	28
1.4.2 Principle of virtual work	29
1.4.3 Theorems of Clapeyron and Betti	30
1.5 Plane problems	31
1.5.1 Plane stress, plane strain, longitudinal shear	31
1.5.2 Linear elasticity, complex method	33
1.5.3 Perfectly plastic material, slip line fields	35
1.6 Further reading	38
2 Classical fracture and failure hypotheses	39
2.1 Basic concepts	39
2.2 Failure hypotheses	40
2.2.1 Principal stress hypothesis	41
2.2.2 Principal strain hypothesis	41
2.2.3 Strain energy hypothesis	42
2.2.4 Coulomb-Mohr hypothesis	43
2.2.5 Drucker-Prager hypothesis	46
2.3 Deformation behavior during failure	47
2.4 Further reading	48

3	Micro and macro phenomena of fracture	49
3.1	Microscopic aspects	49
3.1.1	Surface energy, theoretical strength	49
3.1.2	Microstructure and defects	51
3.1.3	Crack formation	52
3.2	Macroscopic aspects	54
3.2.1	Crack growth	54
3.2.2	Types of fracture	55
3.3	Further reading	57
4	Linear fracture mechanics	59
4.1	General remarks	59
4.2	Crack-tip field	60
4.2.1	Two-dimensional crack-tip fields	60
4.2.2	Mode-I crack-tip field	66
4.2.3	Three-dimensional crack-tip field	67
4.3	K -concept	68
4.4	K -factors	70
4.4.1	Examples	70
4.4.2	Integral equation formulation	77
4.4.3	Method of weight functions	79
4.4.4	Crack interaction	82
4.5	Fracture toughness K_{Ic}	87
4.6	Energy balance	89
4.6.1	Energy release during crack propagation	89
4.6.2	Energy release rate	91
4.6.3	Compliance, energy release rate, and K -factors	94
4.6.4	Energy balance, Griffith's fracture criterion	95
4.6.5	J -integral	100
4.7	Small-scale yielding	107
4.7.1	Plastic zone size, Irwin's crack length correction	107
4.7.2	Qualitative remarks on the plastic zone	109
4.8	Stable crack growth	111
4.9	Mixed-mode loading	114
4.10	Fatigue crack growth	120
4.11	Interface cracks	121
4.12	Piezoelectric materials	130
4.12.1	Basic principles	130
4.12.2	The crack in a ferroelectric material	132
4.13	Further reading	134

5	Elastic-plastic fracture mechanics	137
5.1	Introduction	137
5.2	Dugdale model	138
5.3	Crack-tip field	142
5.3.1	Perfectly plastic material	142
5.3.2	Total strain theory, HRR-field	147
5.4	Fracture criterion	153
5.5	Determination of J	155
5.6	Determination of J_c	156
5.7	Crack propagation	160
5.7.1	J -controlled crack growth	160
5.7.2	Stable crack growth	162
5.7.3	Steady-state crack growth	164
5.8	Essential work of fracture	170
5.9	Further reading	172
6	Creep fracture	173
6.1	Introduction	173
6.2	Fracture of linear viscoelastic materials	174
6.2.1	Crack-tip field, elastic-viscoelastic analogy	174
6.2.2	Fracture concept	176
6.2.3	Crack propagation	178
6.3	Creep fracture of nonlinear materials	182
6.3.1	Secondary creep, constitutive law	182
6.3.2	Stationary crack, crack-tip field, loading parameters	183
6.3.3	Creep crack growth	187
6.4	Further reading	193
7	Dynamic fracture mechanics	195
7.1	Introduction	195
7.2	Some foundations of elastodynamics	196
7.3	Dynamic loading of a stationary crack	197
7.3.1	Crack-tip field, K -concept	197
7.3.2	Energy release rate, energetic fracture criterion	198
7.3.3	Examples	199
7.4	Crack propagation	202
7.4.1	Crack-tip field	202
7.4.2	Energy release rate	206
7.4.3	Fracture concept, crack-tip speed, crack branching, crack arrest	207
7.4.4	Examples	210
7.5	Further reading	215

8	Micromechanics and homogenization	217
8.1	Introduction	217
8.2	Selected defects and fundamental solutions	219
8.2.1	Eigenstrain, Eshelby's result, defect energies	219
8.2.2	Inhomogeneities, the concept of equivalent eigenstrain	228
8.3	Effective elastic properties	233
8.3.1	Foundations; RVE concept, averaging	234
8.3.2	Analytical approximations	243
8.3.3	Energy methods and bounds	263
8.4	Homogenization of elastic-plastic materials	270
8.4.1	Foundations; macroscopic plastic strain, dissipation, macroscopic yield condition	270
8.4.2	Approximations	279
8.5	Thermoelastic material	284
8.6	Further reading	286
9	Damage mechanics	289
9.1	Introduction	289
9.2	Foundations	290
9.3	Brittle damage	292
9.4	Ductile damage	296
9.4.1	Void growth	296
9.4.2	Damage models	298
9.4.3	Fracture concept	300
9.5	Further reading	301
10	Probabilistic fracture mechanics	303
10.1	Introduction	303
10.2	Foundations	304
10.3	Statistical fracture concept of Weibull	307
10.3.1	Fracture probability	307
10.3.2	Fracture stress	309
10.3.3	Generalizations	310
10.4	Probabilistic fracture mechanical analysis	311
10.5	Further reading	312
	Index	315

Fracture Mechanics

With an Introduction to Micromechanics

Gross, D.; Seelig, Th.

2006, XII, 321 p. 166 illus., Hardcover

ISBN: 978-3-540-24034-1