

Fracture Mechanics Topics & References

Color Code: Covered, [Brief Discussion](#), Not Covered

1. Preliminaries: Tensors; Kinematics (displacement, strain); Stress; Balance laws; Constitutive equations
Saouma 5.1-5.4; Anderson A2.1
2. History
Anderson 1.2.1-1.2.5
3. Fracture modes
 - 3.1. Classification
Murakami 1.1.1, 1.1.2, **1.1.3**; Saouma **4.1-4.4** (buckling, fracture, yielding, etc.); Schreurs 2.1.
 - 3.2. Ductile fracture
 - 3.2.1. Dislocation dynamics
Hertzberg 2 (theory), 3 (slip and twinning)
 - 3.2.2. [Void nucleation, growth, and coalescence](#)
Anderson **5.1**;
 - 3.3. [Brittle fracture](#)
Anderson 5.2; Lawn
 - 3.4. [Ductile-brittle transition](#)
 - 3.4.1. [Temperature](#)
Anderson 5.3
 - 3.4.2. [Radiation embrittlement](#)
Hertzberg 10.6.3
 - 3.4.3. [Strain rate](#)
 - 3.4.4. [Hertzberg 5.2](#)
 - 3.4.5. [Hydrogen embrittlement](#)
Anderson 11.4; Hertzberg 11.1
 - 3.4.6. [Size effect](#)
Saouma 16.2.3 (Bazant), 16.2.4 (Carpintieri)
4. Linear Elastic Fracture Mechanics (LEFM)
 - 4.1. Griffith energy approach
 - 4.1.1. Atomic view of fracture; mismatch with experiments
Anderson 2.1; Saouma 8.1.1
 - 4.1.2. Effect of flaws, Griffith experiment
Anderson 2.1; Saouma 8.2
 - 4.1.3. Energy equation, Fracture Resistance (R)
Anderson 2.3; Saouma 9.1
 - 4.1.4. Energy Release Rate (G)
Anderson 2.4
 - 4.1.5. Crack Stability, R and Π curve
Anderson 2.5; Saouma 9.1.2, 9.3
 - 4.2. Stress solutions, Stress Intensity Factor K (SIF)
 - 4.2.1. Airy stress functions
Anderson A2.1; Saouma 5.6
 - 4.2.2. Complex variables and cylindrical coordinate
Saouma 5.7, 5.8; Zender 2.4

- 4.2.3. Stress solutions, stress concentration
 - Saouma 6.1, 6.3, **6.5** A2.3
- 4.2.4. Crack tip stress fields, SIF
 - Saouma 6.4; Schreurs 6.3-6.6; Anderson A2.3
- 4.2.5. Relation between K & R (SIF & Resistance)
 - Saouma **9.2**; Anderson 2.7;
- 4.2.6. SIF Handbooks, design
 - Saouma **7.2**; Schreurs **6.7**; Anderson 2.6.3; Laham
- 4.3. Mixed mode fracture
 - Saouma **10.1**; Schreurs **7.3**; Lawn **2.8**
- 4.4. Crack interactions
 - Anderson 2.12
- 5. Elastoplastic fracture mechanics
 - 5.1. Introduction to plasticity
 - Saouma **2**; Schreurs 9.1-9.4
 - 5.2. Plastic zone models
 - 5.2.1. Irwin, Dugdale, and Barenbolt models
 - Saouma **11.1**; Anderson 2.8
 - 5.2.2. Plane stress versus plane strain plastic zones
 - Saouma 11.2-11.3
 - 5.3. J Integral
 - 5.3.1. Path independence
 - Saouma 13.2; Anderson 3.2.2
 - 5.3.2. Relation between J and G
 - Saouma **13.3**, 13.4; Anderson 3.2.1
 - 5.3.3. Relation between J and K
 - Saouma 13.10; Anderson 3.2.3
 - 5.3.4. Small scale yielding (SSY) versus large scale yielding (LSY)
 - Schreurs 9.9 (SSY); Anderson 3.6.1 (LSY T-stress effect), 3.6.2 (J-Q theory)
 - 5.3.5. Plastic crack tip fields; Hutchinson, Rice and Rosengren solution (HRR)
 - Saouma **13.8**; Schreurs 10.3.1-10.3.2
 - 5.3.6. Crack growth and R curves
 - Anderson 3.4, **3.5**; Saouma 13.6, 13.7
 - 5.4. Crack tip opening displacement (CTOD), relations with J and G
 - Anderson 3.1, **3.3**; Saouma 12
- 6. Computational models
 - 6.1. Traction Separation Relations (TSRs)
 - 6.2. Fracture mechanics in Finite Element Methods (FEM)
 - 6.2.1. Singular stress finite elements
 - Saouma **19.2-19.6**; Schreurs 11.1-11.4
 - 6.2.2. Extraction of K (SIF), G
 - K: Anderson **12.2.1**; Saouma **19.7.1**
 - G: Anderson 12.2.2-12.2.5
 - 6.2.3. J integral
 - Anderson 12.3.3; Saouma 21.1, 21.3.1.1; Schreurs 11.7
 - 6.2.4. Extended Finite Element Method (XFEM)

6.2.5. Adaptive crack tracking

7. Bulk damage models
 - 7.1. Representative Volume Element (RVE) and damage representation
Murakami 1.2, 2.1
 - 7.2. Continuum models based on thermodynamics
 - 7.2.1. Thermodynamic laws, Thermodynamic and dissipation potentials
Murakami 3.1-3.2.2
 - 7.2.2. Damage evolution with plasticity
Murakami 4.1 (1D), 4.2.1-4.2.5 (3D)
 - 7.3. Micromechanics based damage models
 - 7.3.1. Ductile void evolution models
Murakami 6.5.1 (Gurson) & 6.5.2 GTN (Tvergaard & Needleman)
8. Fatigue
Suresh
 - 8.1. Fatigue regimes
 - 8.2. S-N, P-S-N curves
Schreurs 12.3
 - 8.3. Fatigue crack growth models (Paris law)
Anderson 10.2, 10.4 (fatigue threshold); Schreurs 12.5
 - 8.4. Variable and random load
Anderson 10.5; Schreurs 12.6
9. Dynamic fracture mechanics and rate effects
 - 9.1. LEFM solution fields
Freund; Anderson A4.1
 - 9.2. Dynamics of moving crack tip, process zone size, crack speed
Freund; Anderson 4.1.2.2-4.1.2.3
 - 9.3. Crack path instabilities
 - 9.4. Rate effects, viscoelastic and viscoplastic
Anderson 4.3; Kanniwien 2.5, 2.7
 - 9.5. Creep
Kanniwen 7
10. Statistical fracture
 - 10.1. Flaws
Lawn 9 Introduction, 9.1 microcontacts, 9.2 dislocation pile up, 9.3 Chemical, thermal, and radiation source
 - 10.2. Weakest link, Weibull distribution
Anderson A5.1; Lawn 10.1.1
 - 10.3. Probabilistic fracture analysis
Anderson A5.2, Lawn 10.2
11. Experimental fracture
 - 11.1. SIF (K)
Zender 5.5.1-5.5.3
 - 11.2. Fracture toughness
Zender 6
 - 11.3. J
Anderson 3.2.5