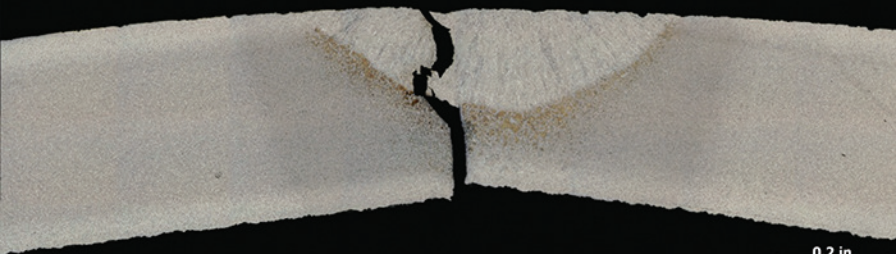


GLOBAL
EDITION

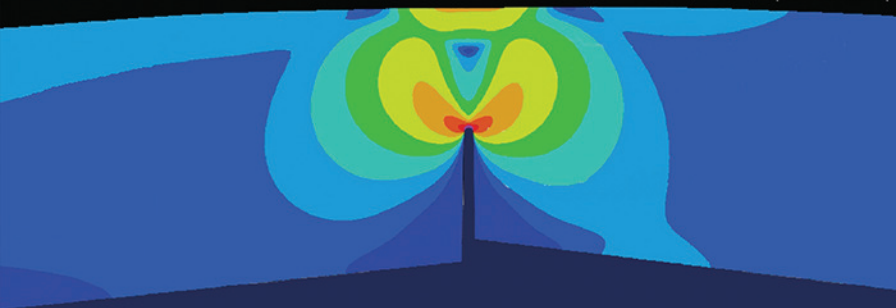


Mechanical Behavior of Materials

Engineering Methods for Deformation, Fracture, and Fatigue



0.2 in



FIFTH EDITION

Norman E. Dowling
Stephen L. Kampe
Milo V. Kral

MATERIALS PROPERTIES LOCATOR

Table No.	Page	Material Type	Data Listed
2.2	57	Whiskers, fibers, wires	E, σ_u
3.2	90	Metals	$E, \sigma_o, \sigma_u, 100\epsilon_f, \%RA$
3.3	91	Polymers	$E, \sigma_o, \sigma_f, 100\epsilon_f, \text{Izod energy}, T_d$
3.4	92	Ceramics, glasses, stone	$T_m, \rho, E, \sigma_u, \sigma_{uc}$
3.5	93	SiC in Al composite	$E, \sigma_o, \sigma_u, 100\epsilon_f$
3.7	107	Metals	$\tilde{\sigma}_{fB}, \tilde{\epsilon}_f, H, n, HB$
3.8	108	Representative	E, σ_o or $\sigma_u, \rho, \text{cost}$
4.1	134	Ceramics, glasses	E, σ_{fb}, HV
5.2	166	Metals, polymers, ceramics	E, ν
5.3	181	Fibers, epoxy, composites	E, G, ν, ρ
7.1	266	Stone, concrete, gray iron	$\sigma_u, \sigma_{uc}, \text{C-M fitting constants}$
8.1	300	Metals	K_{Ic} ; also $\sigma_o, \sigma_u, 100\epsilon_f, \%RA$
8.2	301	Polymers, ceramics	K_{Ic}
9.1	383	Metals	σ_a-N_f constants; also $\sigma_o, \sigma_u, \tilde{\sigma}_{fB}$
10.1	464	Metals	Fatigue limit estimates
10.2	480	Metals	$S-N$ curve estimates at 10^3 cycles
11.1	524	Steels by class	$da/dN-\Delta K$ constants
11.2	535	Steels, aluminums	$da/dN-\Delta K$ constants (Walker); also K_{Ic}, σ_o
11.3	538	Metals	$da/dN-\Delta K$ constants (Forman); also K_{Ic}, σ_o
12.1	594	Metal alloys	$K_{IEAC}, \dot{a}, K_{Ic}$
12.5	605	Solvents, polymers	δ_e, δ_p
13.1	641	Steels, aluminums	E, H', n' ; also σ_o, σ_u
15.1	727	Metals	ϵ_a-N_f constants; E, H', n' ; $\sigma_o, \sigma_u, \tilde{\sigma}_{fB}, \%RA$
16.3	802	Metals	L-M parameter constants
16.4	816	Metals	$\sigma-\epsilon-t$ nonlinear creep constants
B.5	881	Metals, stone, concrete	K_{Ic} and statistics; also σ_o or σ_{uc}
C.1	886	Metals, alloys	T_m, ρ, E
C.9	907	Polymers	T_g, T_m

Explanation of Symbols for Materials Properties

\dot{a}	Crack velocity	T_m	Melting temperature
E	Elastic modulus	δ_e, δ_p	Solubility parameters
G	Shear modulus	$100\epsilon_f$	Percent elongation
H, n	Monotonic $\sigma-\epsilon$ constants	$\tilde{\epsilon}_f$	True fracture strain
H', n'	Cyclic $\sigma-\epsilon$ constants	ν	Poisson's ratio
HB	Brinell hardness	ρ	Density
HV	Vickers hardness	σ_f	Engineering fracture strength
K_{Ic}	Plane strain fracture toughness	$\tilde{\sigma}_{fB}$	True fracture strength
K_{IEAC}	Environmental cracking threshold	σ_{fb}	Bend strength
$\%RA$	Percent reduction in area	σ_o	Yield strength
T_d	Heat deflection temperature	σ_u	Ultimate tensile strength
T_g	Glass transition temperature	σ_{uc}	Ultimate compressive strength

Mechanical Behavior of Materials, Global Edition

Table of Contents

Front Cover

Title Page

Copyright Page

Contents

Preface

Acknowledgments

1 Introduction

1.1 Introduction

1.2 Types of Material Failure

1.3 Design and Materials Selection

1.4 Technological Challenge

1.5 Economic Importance of Fracture

1.6 Summary

References

Problems and Questions

2 Structure, Defects, and Deformation in Materials

2.1 Introduction

2.2 Bonding in Solids

2.3 Structure in Crystalline Materials

2.4 Defects in Materials

2.5 Elastic Deformation and Theoretical Strength

Table of Contents

2.6 Inelastic Deformation

2.7 Summary

References

Problems and Questions

3 Mechanical Testing: Tension Test and StressStrain Mechanisms

3.1 Introduction

3.2 Introduction to Tension Test

3.3 Engineering StressStrain Properties

3.4 Materials Science Description of Tensile Behavior

3.5 Trends in Tensile Behavior

3.6 True StressStrain Interpretation of Tension Test

3.7 Materials Selection for Engineering Components

3.8 Summary

References

Problems and Questions

4 Mechanical Testing: Additional Basic Tests

4.1 Introduction

4.2 Compression Test

4.3 Hardness Tests

4.4 Notch-Impact Tests

4.5 Bending and Torsion Tests

4.6 Summary

References

Problems and Questions

5 StressStrain Relationships and Behavior

Table of Contents

5.1 Introduction

5.2 Models for Deformation Behavior

5.3 Elastic Deformation

5.4 Anisotropic Materials

5.5 Summary

References

Problems and Questions

6 Review of Complex and Principal States of Stress and Strain

6.1 Introduction

6.2 Plane Stress

6.3 Principal Stresses and the Maximum Shear Stress

6.4 Three-Dimensional States of Stress

6.5 Stresses on the Octahedral Planes

6.6 Complex States of Strain

6.7 Summary

References

Problems and Questions

7 Yielding and Fracture Under Combined Stresses

7.1 Introduction

7.2 General Form of Failure Criteria

7.3 Maximum Normal Stress Fracture Criterion

7.4 Maximum Shear Stress Yield Criterion

7.5 Octahedral Shear Stress Yield Criterion

7.6 Discussion of the Basic Failure Criteria

7.7 CoulombMohr Fracture Criterion

7.8 Modified Mohr Fracture Criterion

Table of Contents

7.9 Additional Comments on Failure Criteria

7.10 Summary

References

Problems and Questions

8 Fracture of Cracked Members

8.1 Introduction

8.2 Preliminary Discussion

8.3 Mathematical Concepts

8.4 Application of K to Design and Analysis

8.5 Additional Topics on Application of K

8.6 Fracture Toughness Values and Trends

8.7 Plastic Zone Size, and Plasticity Limitations on LEFM

8.8 Discussion of Fracture Toughness Testing

8.9 Extensions of Fracture Mechanics Beyond Linear Elasticity

8.10 Summary

References

Problems and Questions

9 Fatigue of Materials: Introduction and Stress-based Approach

9.1 Introduction

9.2 Definitions and Concepts

9.3 Sources of Cyclic Loading

9.4 Fatigue Testing

9.5 The Physical Nature of Fatigue Damage

9.6 Trends in S-N Curves

9.7 Mean Stresses

9.8 Multiaxial Stresses

Table of Contents

9.9 Variable Amplitude Loading

9.10 Summary

References

Problems and Questions

10 Stress-based Approach to Fatigue: Notched Members

10.1 Introduction

10.2 Notch Effects

10.3 Notch Sensitivity and Empirical Estimates of k_f

10.4 Estimating Long-Life Fatigue Strengths (Fatigue Limits)

10.5 Notch Effects at Intermediate and Short Lives

10.6 Combined Effects of Notches and Mean Stress

10.7 Estimating S-N Curves

10.8 Use of Component S-N Data

10.9 Designing to Avoid Fatigue Failure

10.10 Discussion

10.11 Summary

References

Problems and Questions

11 Fatigue Crack Growth

11.1 Introduction

11.2 Preliminary Discussion

11.3 Fatigue Crack Growth Rate Testing

11.4 Effects of $R = S_{min}/S_{max}$ on Fatigue Crack Growth

11.5 Trends in Fatigue Crack Growth Behavior

11.6 Life Estimates for Constant Amplitude Loading

11.7 Life Estimates for Variable Amplitude Loading

Table of Contents

11.8 Design Considerations

11.9 Plasticity Aspects and Limitations of LEFM for Fatigue Crack Growth

11.10 Summary

References

Problems and Questions

12 Environmentally Assisted Cracking

12.1 Introduction

12.2 Definitions, Concepts, and Analysis

12.3 EAC in Metals: Basic Mechanisms

12.4 Hydrogen-Induced Embrittlement

12.5 Liquid Metal Embrittlement

12.6 EAC of Polymers

12.7 EAC of Glasses and Ceramics

12.8 Additional Comments and Preventative Measures

References

Problems and Questions

13 Plastic Deformation Behavior and Models for Materials

13.1 Introduction

13.2 StressStrain Curves

13.3 Three-Dimensional StressStrain Relationships

13.4 Unloading and Cyclic Loading Behavior from
Rheological Models

13.5 Cyclic StressStrain Behavior of Real Materials

13.6 Summary

References

Problems and Questions

Table of Contents

14 StressStrain Analysis of Plastically Deforming Members

14.1 Introduction

14.2 Plasticity in Bending

14.3 Residual Stresses and Strains for Bending

14.4 Plasticity of Circular Shafts in Torsion

14.5 Notched Members

14.6 Cyclic Loading

14.7 Summary

References

Problems and Questions

15 Strain-Based Approach to Fatigue

15.1 Introduction

15.2 Strain Versus Life Curves

15.3 Mean Stress Effects

15.4 Multiaxial Stress Effects

15.5 Life Estimates for Structural Components

15.6 Additional Discussion

15.7 Summary

References

Problems and Questions

16 Time-Dependent Behavior: Creep and Damping

16.1 Introduction

16.2 Creep Testing

16.3 Physical Mechanisms of Creep

16.4 TimeTemperature Parameters and Life Estimates

16.5 Creep Failure under Varying Stress

Table of Contents

- 16.6 StressStrainTime Relationships
- 16.7 Creep Deformation under Varying Stress
- 16.8 Creep Deformation under Multiaxial Stress
- 16.9 Component StressStrain Analysis
- 16.10 Energy Dissipation (Damping) in Materials
- 16.11 Summary
- References
- Problems and Questions

Appendix A Review of Selected Topics from Mechanics of Materials

- A.1 Introduction
- A.2 Basic Formulas for Stresses and Deflections
- A.3 Properties of Areas
- A.4 Shears, Moments, and Deflections in Beams
- A.5 Stresses in Pressure Vessels, Tubes, and Discs
- A.6 Elastic Stress Concentration Factors for Notches
- A.7 Fully Plastic Yielding Loads
- References

Appendix B Statistical Variation in Materials Properties

- B.1 Introduction
- B.2 Mean and Standard Deviation
- B.3 Normal or Gaussian Distribution
- B.4 Typical Variation in Materials Properties
- B.5 One-Sided Tolerance Limits
- B.6 Discussion
- References

Table of Contents

Appendix C A Survey of Engineering Materials

C.1 Introduction

C.2 Alloying and Processing of Metals

C.3 Irons and Steels

C.4 Nonferrous Metals

C.5 Polymers

C.6 Ceramics and Glasses

C.7 Composite Materials

C.8 Summary

References

Answers for Selected Problems and Questions

Bibliography

Index

Back Cover