CONTENTS

Page

PART ONE: THE FATIGUE PROCESS

1 Fatigue Damage Mechanisms : Introduction **3**
The Fatigue Process 4
Fatigue Damage Characterization 9
Fatigue Reliability 15
Conclusions 21
References 22

2 Fatigue of Composite Materials: Damage Mechanisms and Fatigue-Life Diagrams **25**
Damage Mechanisms in Unidirectional Composites 26
Angle-Plied Laminates 33
Cross-Plied Laminates 35
Other Laminates 35
Fatigue Ratio and Fatigue limit 37
Conclusions 37
References 38

3 **Damage Models for Fatigue of Composite Materials** **41**
Damage Mechanisms 41
Fatigue-Life Diagrams 45
Damage Models 54
Conclusions 57
References 57

4 A Conceptual Framework for the Interpretation of Fatigue Damage Mechanisms in Composite Materials **59**
Conclusions 68
References 69

PATR TWO: FATIGUE DAMAGE CHARACTERIZATION

5 Stiffness Based Fatigue Damage Characterization of Fibrous Composites **73**
Material and Specimen 74
Experimental Procedure 75
Measurement of Elastic Constants 78
Results and Discussion 78
Extension to laminates 80
Conclusions 81
References 81

6 A Continuum Mechanics Characterization of Damage in Composite Materials **83**
Damage 84
Constitutive Equations 87
Residual Elastic Properties 101
Discussion 105
References 107
Appendix A Transversely Isotropic Materials 109

Appendix B Orthotropic Materials 110

7 Residual Stiffness Properties of Cracked Composite Laminates 113
Elastic Response of Cracked Laminates 114
Residual Stiffness Properties 117
Prediction of Stiffness Reductions 120
References 122

8 Transverse Cracking and Stiffness Reduction in Composite Laminates 123
Transverse Cracking Effects on Stress-Strain Response 124
Stiffness-Transverse Cracking Relationships 128
Elastic Moduli Predictions 134
Conclusions 144
References 144

PART THREE: FATIGUE RELIABILITY

9 Estimation of Weibull Parameters for Composite Material Strength and Fatigue Life Data 149
Estimation of Weibull parameters 150
Estimation from Random Samples 157
Estimation from Composite Material Strength and Fatigue Life Data 165
Conclusions 167
References 168

10 On Design Criteria for Composite Structures Under Static and Fatigue Loads 169
Static Loads 170
Fatigue Loads 175
References 180

Index 181