

CONTENTS

	Page
Preface	ix
Notation	xiii
Part 1 Basic Concepts and Experiments	
1 Introduction	3
1.1 Introduction	3
1.2 Constitutive Modeling of Reinforced Concrete	6
1.3 Finite-Element Modeling of Reinforced Concrete	14
1.4 The Literature of the State of the Art	16
1.5 Summary	17
References	18
2 Some Basic Properties of Concrete and Steel	19
2.1 Introduction	19
2.2 Uniaxial Behavior of Concrete	20
2.3 Biaxial Behavior of Concrete	26
2.4 Triaxial Behavior of Concrete	39
2.5 Stress-Strain Relations for Steel	42
2.6 Summary	45
References	47
Part 2 Concrete Elasticity and Failure Criteria	
3 Linear-Elastic Brittle-Fracture Models	51
3.1 Introduction	51
3.2 Index Notation and Summation Convention	52
3.3 Analysis of Stress	65
3.4 Analysis of Strain	72
3.5 Linear-Elastic Isotropic Stress-Strain Relations for Uncracked Concrete	76
3.6 Linear-Elastic Transversely Isotropic Stress-Strain Relations for Cracked Concrete	81
3.7 Linear-Elastic Fracture Analysis of Undersea Pressure-Resistant Concrete Structures	94
3.8 Linear-Elastic Fracture Analyses of Beams	107
3.9 Inelastic Analysis of Reinforced Concrete Panels	115
3.10 Summary	120
References	122
4 Nonlinear-Elastic Fracture Models	124
4.1 Introduction	124
4.2 Isotropic Nonlinear-Elastic Stress-Strain Relations by Modification of the Linear-Elastic Models	130
4.3 General Formulation of Hyperelastic Models	144
4.4 Formulation of a Third-Order Hyperelastic Constitutive Model	163
4.5 Incremental Stress-Strain Relations by Modification of the Linear-Elastic Models	167
4.6 General Formulation of Isotropic Hypoelastic Models	173
4.7 Formulation of an Orthotropic Hypoelastic Constitutive Model for Concrete	176
4.8 Summary	185
References	188
5 Failure Criteria of Concrete	190
5.1 Introduction	190
5.2 Stress and Strain Invariants	191

5.3	Characteristics of the Failure Surface of Concrete	201
5.4	One-Parameter Models	204
5.5	Two-Parameter Models	210
5.6	Three-Parameter Models	217
5.7	Four-Parameter Models	225
5.8	A Five-Parameter Model	240
5.9	A Fracture Model	245
5.10	Summary	248
	References	249

Part 3 Concrete Plasticity : Theory and Application

6	Elastic Perfectly Plastic Fracture Models	253
6.1	Introduction	253
6.2	Criteria of Loading and Unloading	254
6.3	Elastic-Strain-Increment Tensor	257
6.4	Plastic-Strain-Increment Tensor	257
6.5	Elastic Perfectly Plastic Concrete Models	262
6.6	Prandtl-Ruess Material	264
6.7	Drucker-Prager Material	270
6.8	Mohr-Coulomb Material with a Tension Cutoff	282
6.9	William-Warnke Material	288
6.10	Summary	292
	References	294
7	Limit Analysis of Perfect Plasticity	295
7.1	Introduction	295
7.2	The Theorems of Limit Analysis	297
7.3	A Plasticity Model for Concrete	301
7.4	Splitting Tests on Cylinders	306
7.5	Shear Resistance of Joints	311
7.6	Shear in Beams with Vertical Stirrups	321
7.7	Punching Shear of Reinforced Concrete Slabs	328
7.8	Load-Carrying Capacity of Concrete Pavements	333
7.9	Summary	342
	References	344
8	Elastic-Hardening Plastic-Fracture Models	347
8.1	Introduction	347
8.2	Loading Function and the Concept of Effective Stress and Effective Strain	349
8.3	Hardening Rule	352
8.4	Flow Rule and Drucker's Stability Postulate	356
8.5	Incremental Stress-Strain Relation	360
8.6	Drucker-Prager Material with a Cap Displaying Isotropic Hardening and Softening	361
8.7	Von Mises Material Displaying Mixed Hardening	369
8.8	A Three-Parameter Model for Concrete Displaying Isotropic Hardening	376
8.9	A Three-Parameter Model for Concrete Displaying Independent Hardening in Tension and in Compression	384
8.10	Summary	390
	References	392
9	Numerical Implementation of Elastoplastic Fracture Models	394
9.1	Introduction	394
9.2	The Finite-Element Process in Displacement Analysis	395
9.3	Numerical Implementation of Elastoplastic Models	402
9.4	An Example of Elastoplastic Analysis	406
9.5	Finite-Element Analysis of Fractured Concrete	416
9.6	Examples of Elastoplastic Fracture Analysis	421
9.7	Nonlinear Analysis of External-Pressure-Resistant Concrete-Cylinder Shells	429
9.8	Nonlinear Analysis of Top Closure of Prestressed Concrete Reactor Vessel	453

9.9 Summary	457
References	459
Additional References on the Application of Finite-Element Analysis to Reinforced Concrete Structures	461
Index	465