
Contents

Preface	xiii
Chapter 1. Some Issues Related to the Modeling of Dynamic Shear Localization-assisted Failure	
Patrice LONGÈRE	
1.1. Introduction	1
1.2. Preliminary/fundamental considerations	3
1.2.1. Localization and discontinuity	3
1.2.2. Isothermal versus adiabatic conditions	6
1.2.3. Sources of softening	9
1.2.4. ASB onset	22
1.2.5. Scale postulate	26
1.3. Small-scale postulate-based approaches	27
1.3.1. Material of the band viewed as an extension of the solid material behavior before ASB onset	28
1.3.2. Material of the band viewed as a fluid material	29
1.3.3. ASB viewed as a damage mechanism	31
1.3.4. Assessment	32
1.4. Embedded band-based approaches (large-scale postulate)	33
1.4.1. Variational approaches	34
1.4.2. Enriched finite element kinematics	38
1.4.3. Enriched constitutive model	41
1.4.4. Discussion	43
1.5. Conclusion	44
1.6. Acknowledgments	45
1.7. References	45

**Chapter 2. Analysis of the Localization Process Prior
to the Fragmentation of a Ring in Dynamic Expansion** 53

Skander EL MAÏ, Sébastien MERCIER and Alain MOLINARI

2.1. Introduction	53
2.1.1. Fragmentation experiments	54
2.1.2. Fragmentation theories	54
2.2. An extension of a linear stability analysis developed in [MER 03]	59
2.2.1. Position of the problem.	59
2.2.2. Classical linear stability analysis	60
2.2.3. Evolution of the cross-section perturbation.	62
2.2.4. Analysis of the potential sites of necking.	65
2.3. Outcomes of the approach	70
2.3.1. Effects of the loading velocity on neck spacing distribution	70
2.3.2. Effects of an imposed dominant mode in the initial perturbation	72
2.3.3. Comparison of the approach with numerical simulations	83
2.4. Conclusion	89
2.5. References	90

**Chapter 3. Gradient Damage Models Coupled With Plasticity
and Their Application to Dynamic Fragmentation** 95

Arthur GEROMEL FISCHER and Jean-Jacques MARIGO

3.1. Introduction	95
3.2. Theoretical aspects	96
3.2.1. Gradient damage models	96
3.2.2. Damage coupled with plasticity	106
3.2.3. Dynamic gradient damage	117
3.3. Numerical implementation	122
3.4. Applications	123
3.4.1. 1D fracture	124
3.4.2. Material behavior	124
3.4.3. Dimensionless parameters	126
3.4.4. 1D period bar	131
3.4.5. Cylinder under internal pressure.	135
3.5. Conclusion	138
3.6. References	139

Chapter 4. Plastic Deformation of Pure Polycrystalline Molybdenum	143
Geremy J. KLEISER, Benoit REVIL-BAUDARD and Oana CAZACU	
4.1. Introduction	143
4.2. Quasi-static and dynamic data on a pure polycrystalline Mo	144
4.2.1. Analysis of the quasi-static uniaxial tension test results on smooth specimens	147
4.2.2. Split Hopkinson pressure bar data	154
4.2.3. Taylor cylinder impact data	155
4.3. Constitutive model for polycrystalline Mo	158
4.4. Predictions of the mechanical response	162
4.4.1. FE predictions of the quasi-static uniaxial tensile response for notched specimens	162
4.5. Conclusions	172
4.6. References	173
Chapter 5. Some Advantages of Advanced Inverse Methods to Identify Viscoplastic and Damage Material Model Parameters	177
Bertrand LANGRAND, Delphine NOTTA-CUVIER, Thomas FOUREST and Eric MARKIEWICZ	
5.1. Introduction	177
5.2. Experimental devices for material characterization over a large range of strain rates	180
5.3. Identification of elasto-viscoplastic and damage material Parameters	184
5.3.1. Direct approach for material parameter identification	184
5.3.2. Inverse approaches for material parameter identification	192
5.4. Conclusions	204
5.5. Acknowledgments	205
5.6. References	205
Chapter 6. Laser Shock Experiments to Investigate Fragmentation at Extreme Strain Rates	213
Thibaut DE RESSÉGUIER, Didier LOISON, Benjamin JODAR, Emilien LESCOUTE, Caroline ROLAND, Loïc SIGNOR and André DRAGON	
6.1. Introduction	214
6.2. Phenomenology of laser shock-induced fragmentation	215
6.3. Spall fracture	217

6.4. Microspall after shock-induced melting	222
6.5. Microjetting from geometrical defects	225
6.6. Conclusion	230
6.7. References	231
Chapter 7. One-dimensional Models for Dynamic Fragmentation of Brittle Materials	237
David CERECEDA, Nitin DAPHALAPURKAR and Lori GRAHAM BRADY	
7.1. Introduction	237
7.2. Methods	242
7.3. Results	244
7.3.1. Mono-phase materials	244
7.3.2. Multi-phase materials.	251
7.4. Conclusions	258
7.5. References	259
Chapter 8. Damage and Wave Propagation in Brittle Materials	263
Quriaky GOMEZ, Jia LI and Ioan R. IONESCU	
8.1. Introduction	263
8.2. Short overview of damage models	264
8.2.1. Effective elasticity of a cracked solid	266
8.2.2. Damage evolution.	268
8.3. 1D wave propagation	275
8.3.1. Problem statement	276
8.3.2. A single family of micro-cracks	278
8.3.3. Three families of micro-cracks	280
8.4. Two-dimensional anti-plane wave propagation	280
8.4.1. Anisotropic damage under isotropic loading	281
8.4.2. Anisotropic loading of an initial isotropic damaged material	284
8.5. Blast impact and damage evolution	286
8.6. Conclusions and perspectives.	291
8.7. Acknowledgments	292
8.8. References	292

Chapter 9. Discrete Element Analysis to Predict Penetration and Perforation of Concrete Targets Struck by Rigid Projectiles	297
Laurent DAUDEVILLE, Andria ANTONIOU, Ahmad OMAR, Philippe MARIN, Serguei POTAPOV and Christophe PONTIROLI	
9.1. Introduction	297
9.2. Discrete element model	299
9.2.1. Definition of interactions	299
9.2.2. Constitutive behavior of concrete: Discrete element model	300
9.2.3. Linear elastic constitutive behavior.	301
9.2.4. Nonlinear constitutive behavior.	302
9.2.5. Strain rate dependency.	305
9.3. Simulation of impacts	307
9.3.1. Impact experiments	307
9.3.2. Modeling of impact experiments	308
9.4. Conclusion.	311
9.5. References	311
Chapter 10. Bifurcation Micromechanics in Granular Materials	315
Antoine WAUTIER, Jiaying LIU, François NICOT and Félix DARVE	
10.1. Introduction	315
10.2. Application of the second-order work criterion at representative volume element scale	318
10.3. From macro to micro analysis of instability.	322
10.3.1. Local second-order work and contact sliding	322
10.3.2. Role of strong contact network in stable and unstable loading directions	323
10.3.3. From contact sliding to mesoscale mechanisms	326
10.3.4. Micromechanisms leading to bifurcation at the representative volume element scale	329
10.4. Diffuse and localized failure in a unified framework.	331
10.4.1. Diffuse and localized failure pattern	331
10.4.2. Common micromechanisms and microstructures	332
10.5. Conclusion	334
10.6. References	335

**Chapter 11. Influence of Specimen Size on the
Dynamic Response of Concrete** 339

Xu NIE, William F. HEARD and Bradley E. MARTIN

11.1. Introduction	339
11.2. Materials and specimens	341
11.3. Experimental techniques	343
11.3.1. Kolsky compression bar theory and set-up	343
11.3.2. Pulse shaping technique	345
11.4. Results and discussion	350
11.4.1. Pulse shaper design for Kolsky compression bar systems	350
11.4.2. Rate and specimen size effect on failure strength	355
11.5. Conclusion	360
11.6. Acknowledgments	362
11.7. References	362

**Chapter 12. Shockless Characterization of Ceramics
Using High-Pulsed Power Technologies** 365

Jean-Luc ZINSZNER, Benjamin ERZAR and Pascal FORQUIN

12.1. Introduction	365
12.1.1. Presentation of the silicon carbide grades	367
12.2. Principle of the GEPI generator	368
12.3. Dynamic compression of ceramics	370
12.3.1. Lagrangian analysis of velocity profiles	371
12.3.2. Experimental results	372
12.4. Dynamic tensile strength of ceramics	374
12.4.1. Experimental methodology and data processing	375
12.4.2. Characterization of two silicon carbide grades	377
12.4.3. Post-mortem analyses of damaged samples	378
12.5. Conclusions	380
12.6. Acknowledgments	381
12.7. References	381

**Chapter 13. A Eulerian Level Set-based Framework for
Reactive Meso-scale Analysis of Heterogeneous
Energetic Materials** 387

Nirmal KUMAR RAI and H.S. UDAYKUMAR

13.1. Introduction	387
13.2. Numerical framework	390
13.2.1. Governing equations	390

13.2.2. Constitutive model for HMX	390
13.2.3. Reactive modeling of HMX	393
13.2.4. Level set representation of embedded interface	395
13.2.5. Image processing approach: Representing real geometries	395
13.3. Results	398
13.3.1. Grid refinement study	400
13.3.2. Collapse behavior of voids present in the pressed HMX material	401
13.3.3. Criticality conditions for Class III and Class V samples	403
13.3.4. Meso-scale criticality conditions for pressed energetic materials	405
13.4. Conclusions	411
13.5. Acknowledgments	412
13.6. References	412
Chapter 14. A Well-posed Hypoelastic Model Derived From a Hyperelastic One	417
Nicolas FAVRIE and Sergey GAVRILYUK	
14.1. Introduction	417
14.2. A general hyperelastic model formulation	418
14.3. Evolution equation for the deviatoric part of the stress tensor: neo-Hookean solids	420
14.3.1. Expression of $\text{tr}(b)$ as a function of the invariants of S	421
14.3.2. Hypoelastic formulation	423
14.4. Conclusions	424
14.5. Acknowledgments	425
14.6. References	425
Appendix A: Case $a = 0.5$	429
List of Authors	433
Index	437
