

Index

a

acoustic tensor 393
 algorithmic modulus 28
 analysis
 dynamic 21, 29, 85, 269
 inverse 279, 370
 quasi-static 28, 85
 rigid-plastic 322
 second-order 121, 366
 transient 29, 50, 103, 384
 angle
 cross-section rotation 68, 82, 287
 dilatancy 181
 external friction 179
 internal friction 179
 shear 68, 74, 87, 99, 287
 anisotropy 161, 176, 267
 load-induced 154, 166, 172, 189, 194, 198, 222, 265, 268, 272, 348
 arc length method 42, 97, 124, 144, 233, 388
 area coordinates 298, 299, 301, 405

b

benchmark 9
 blind 380
 Bernoulli beam 68, 71, 85, 112, 123, 280
 element 88, 93, 120, 281
 enhanced element 91, 95, 96, 111, 124, 129
 Bernoulli–Navier hypothesis 67, 115, 286, 296, 330
 BFGS method 61, 107, 384

bond

266
 flexible 55, 63, 266, 280, 284
 law 55, 60, 266, 275, 280, 284
 rigid 65, 73, 266, 268, 273, 296, 346, 396
 boundary conditions
 Dirichlet 11, 31
 displacement 11, 95
 forces 12, 31
 Neumann 12, 31
 Bubnov–Galerkin 22, 86

c

calibration 9, 47, 186, 197
 characteristic length 42
 cohesive 203, 222
 element 211, 217, 265
 non-local 215, 233
 characteristic value 371
 Clausius–Duhem inequality 199
 cohesive zone 41, 202
 compliance 20, 46, 57, 162, 189, 221
 compression field theory 250
 consistency condition 174, 185, 190, 191
 constraint
 force 106, 111
 microplane kinematic 193
 multi-plane static 193
 stress 50, 51
 continuity 34
 C^0 18, 87, 90
 C^1 295, 298, 301
 C^2 90

- convergence
 - equilibrium iteration 27
 - FEM 31, 33
 - Γ 232
 - Newton–Raphson 27, 381
- coordinate system
 - Cartesian 13, 401
 - contravariant 333
 - corotational 119, 336, 339, 345
 - covariant 333
 - local 14
 - transformation 157, 402
- correlation 355, 362, 367, 369
- crack
 - bridge 40, 202
 - closure 223, 241, 262, 263, 265
 - cohesive 43, 56, 59, 152, 202, 241, 264, 382
 - compliance 204, 218
 - dual 264, 270, 348
 - fictitious 43, 152, 202, 203
 - fixed 223, 240, 261
 - formation 62, 65, 97, 110, 270, 349, 395, 400
 - initiation 218, 236, 261, 394
 - macro 40, 56, 152, 202, 223, 262, 264
 - micro 40, 152, 153, 191, 223
 - path tracking 236
 - propagation 201, 222, 229, 236, 261
 - rotating 223, 240, 261, 264, 265
 - smeared 56, 59, 198, 205, 213, 216, 222, 261, 268
 - spacing 109, 398
 - stabilised 62, 65, 97, 109, 270, 349, 398, 399
 - strain 56, 216, 219
 - tangential plane 203, 216
- crack band 41
 - approach 205, 210, 213, 222
 - width 43, 56, 210, 215, 218, 221, 235, 269
- crack energy
 - surface 44, 58, 154, 203, 206, 209, 219, 233, 269
 - volume 44, 221
- crack width
 - critical 44, 203, 222
 - fictitious 43, 57, 202, 216, 237
- creep 45
 - coefficient 48, 50
 - function 45, 47
 - linear 45, 47
 - time 48, 50
- d**
- damage 153, 172
 - anisotropic 189
 - gradient 42, 223, 226, 235
 - isotropic 183, 189, 207, 224, 269, 348
 - microplane 195, 271, 351
 - orthotropic 189
 - strain-based 183, 185, 190, 192, 196
 - stress-based 183, 185, 190
 - variable 183, 190, 196
- damage function 184
 - Hsieh–Ting–Chen 184, 188, 207, 269, 348
 - microplane 195
 - Rankine 184
- damping 131, 383
- design
 - deterministic 370
 - probabilistic 370
 - semi-probabilistic 361, 371, 372
- design point 359, 363, 365
- deviatoric
 - length 167, 169, 175, 178, 181, 196
 - plane 167, 168, 178, 181
 - projection 181
- dilatancy 154, 181
- Dirac delta function 46, 239
- discontinuity
 - strong 392
 - weak 392
- discretisation 8
 - spatial 22, 32
 - time 29
 - updated Lagrangian co-rotational 121
- dissipation potential 229
- distribution function 354, 359, 365, 373
- Drucker stability postulate 200, 209

- ductility 44, 53, 80, 148, 149, 260, 311, 327, 368
- dyadic product 175, 188, 239
- e**
 - eigenstress 351
 - eigenvalue problem
 - generalised 122, 127
 - matrix 158, 234
 - Einstein summation convention 193, 391
 - elasto-plasticity 52, 172
 - damaged 190
 - Drucker–Prager 178
 - Mises 175, 177
 - Mohr–Coulomb 179
 - multi-axial 173
 - uniaxial 53, 142, 172
 - element
 - bar 1D 14
 - bar 2D 15
 - Bernoulli beam 88
 - continuum quad 2D 17
 - continuum-based shell 329
 - Kirchhoff slab 299
 - locking 19, 34, 87, 93, 280, 341, 344
 - overlay 268
 - spring 1D 16
 - spring 2D 16
 - Timoshenko beam 86
 - ellipticity loss 209
 - energy
 - dissipation 44, 53, 131, 154, 200, 209
 - internal 18, 157, 199, 229, 289
 - equilibrium
 - dynamic 30
 - incrementally iterative 26, 42, 50, 96, 104, 107, 116, 232, 349
 - strong differential 22, 82, 290
 - weak integral 22, 82, 292
 - error
 - approximation 8, 22, 31
 - discretisation 31, 32
 - modelling 8
 - evolution law 20, 53, 164, 174, 182, 185, 190, 230
- f**
 - failure
 - brittle 202
 - ductile 202
 - quasi-brittle 202, 206
 - failure probability 359, 363, 368, 370
 - fibre model 81, 278, 284
 - flow
 - potential 174, 175
 - rule 145, 173, 175, 180, 191
 - fracture
 - mode 201
 - toughness 229, 235
 - variational model 230
 - fracture mechanics
 - computational 236
 - linear elastic 201
 - function
 - test 21, 22, 31, 82, 85, 136, 224, 230, 292
 - trial 10, 14, 22, 31, 86, 114, 277
- h**
 - Haigh–Westergaard coordinates 167, 178, 186
 - hardening 38, 52
 - isotropic 53, 177
 - modulus 53, 177
 - Heaviside function 46
 - homogeneity 151
 - hour glassing 343
 - hydrostatic
 - axis 167, 180
 - length 167, 179, 181
 - pressure 153, 156, 159, 169, 178
- i**
 - impact 128
 - importance sampling 364, 365
 - instability 122, 391
 - material 391
 - numerical 343
 - structural 125, 391
 - integration
 - Gauss 25, 92, 134, 175
 - numerical 25
 - triangular elements 301



420 | Index

- internal forces
 - beam 70
 - shell 339
 - slab 288
- internal state variable 20, 53, 164, 174, 178, 180, 183, 241, 263
- interpolation 10, 18
 - isoparametric 14, 330
 - mixed 343
- invariant 159, 165, 177
- isotropy 159, 160, 165, 178

- j**
- Jacobian
 - matrix 14, 17, 340
 - scalar 15, 17, 25, 85, 274, 331, 338

- k**
- Kelvin–Voigt
 - chain 47
 - element 47, 131
- kinematic assumption
 - bar 14, 15
 - beam 67
 - continuum 17
 - plate 249
 - shell 332
 - slab 286
 - spring 16
 - truss 138
- Kuhn–Tucker condition
 - damage 185, 196
 - phase field 231
 - plasticity 145, 174, 191

- l**
- layer model 296, 306, 344, 348, 395
- limit state
 - condition 358, 360, 361, 364, 367, 368
 - function 358
 - lower bound 147, 249, 305
 - ultimate 9
 - upper bound 147, 323
- linearity
 - geometrical 13, 118
 - physical 12, 24
- localisation 40, 205, 215, 223, 232, 235

- m**
- mass
 - element matrix 92
 - matrix 23, 30, 94, 383
 - moment 85, 126
 - per length 22, 81, 126
 - specific 21, 82, 126
- material
 - algorithmic tangential stiffness matrix 28, 177
 - damaged 172
 - elasto-plastic 172
 - isotropic linear elastic 160
 - law 11
 - stiffness matrix 13, 20, 90, 141, 160, 173
 - tangential stiffness matrix 20, 38, 79, 142, 157, 164, 175, 182, 297, 382, 391
- Maxwell
 - element 47
 - series 47
- meridian
 - compressive 168, 170, 179, 186
 - tensile 168, 170, 179
- mesh
 - dependency 205, 209
 - generation 22
- modal decomposition 127
- model
 - computational 8
 - conceptual 7
 - mathematical 7
 - numerical 8
- Monte Carlo simulation 364, 367

- n**
- natural
 - circular frequency 127
 - period 126, 127
- Newmark method 29, 128, 382, 383
 - consistency 30
 - stability 30
- Newton–Raphson method 26, 381
 - modified 383

nodal forces
 external 12, 23
 internal 12, 23
 nonlinearity
 geometrical 118
 physical 12
 non-local method 214
 differential 215, 223, 235
 integral 214
 norm 27, 32, 42
 Sobolev 32
 N-standardisation 362, 368

o
 operator
 bilinear 32
 linear 32
 orthotropy 161

p
 parameter 8
 patch test 34
 phase field 228, 232, 235
 plasticity 153
 associated 175
 deviatoric 182
 limit theorems 147, 249, 322
 non-associated 181
 rigid 145
 volumetric 182
 prediction 9
 prestressing
 bonded 113
 post-bonded 113
 tendon 112
 unbonded 113
 principal
 strain 158, 262
 stress 134, 158
 stress space 166, 168, 177, 178
 system 158
 probability 354
 density function 354, 356, 358
 joint density function 358, 361
 process zone 41, 202
 property 7
 punching 314

r
 random variable 357, 360, 363, 373
 bivariate 354, 370
 fractile 360
 multi-variate 354
 univariate 354
 randomness 354, 356, 367
 Rankine
 criterion 216, 218, 222, 236, 261, 394
 limit function 180
 Rayleigh quotient 127
 reference
 axis 67
 configuration 155, 159
 period 357, 359
 plane 286
 surface 329
 regularisation 200, 205, 209, 223,
 237, 265
 softening modulus 210
 reinforcement
 group 252
 integrated 273, 346
 mesh 252, 266
 sheet 267, 296, 346
 relaxation 45, 118
 function 47
 Rendulic direction 167
 representative volume element RVE
 152, 168
 residual 26
 resonance 131
 rheological model 47

s
 safety
 global factor 370, 372
 margin 363, 370
 partial factor 372, 374
 sample 354, 365
 scale
 macro 39, 43, 56, 152, 202
 meso 39, 151, 152, 215
 micro 39, 45, 192
 secant method 383, 389
 serviceability 9, 74, 101, 260

- shear
 - correction factor 70, 290
 - modulus 70, 176, 195, 297, 346
 - retention factor 204
 - stiffness 100
 - shell 329
 - director 330
 - displacement 331
 - five parameter model 334
 - geometry 330
 - shrinkage 49, 105, 259
 - simplex method 147
 - size effect 154
 - slab 285
 - Kirchhoff 287, 291, 295
 - Reissner-Mindlin 287, 295
 - snap-back 42, 205, 388
 - Sobolev
 - function space 31
 - norm 32, 34
 - split
 - normal-tangential 194
 - volumetric-deviatoric 193
 - volumetric-deviatoric-tangential 194
 - stiffness matrix 13
 - tangential 24, 27
 - stochastic FEM 356
 - strain 155
 - assumed natural 343
 - covariant, natural 334
 - equivalent 184, 190, 195
 - generalised 17, 18, 20, 31, 69, 71, 202, 227, 288, 295
 - imposed 49, 105, 400
 - local 336
 - measurable 49, 105
 - non-local 215
 - plane 18, 162
 - rate 157
 - softening 38, 205, 209, 221
 - volumetric 181, 193
 - strength
 - biaxial 171
 - condition 145, 165, 253
 - surface 167, 170, 180, 185
 - triaxial 167, 171
 - uniaxial 171, 216
 - stress
 - Cauchy stress 156, 199, 203, 289, 335, 402
 - contravariant 335
 - deviatoric 156
 - effective 191
 - extension 29
 - generalised 17, 18, 20, 71, 202, 288, 295
 - local 336, 339
 - plane 18, 162
 - rate 157
 - trajectory 135
 - strut 98, 136, 260
 - strut-and-tie model 137, 249, 260, 297
- t**
- temperature 49, 105, 110, 259
 - tension
 - softening 40, 41, 56
 - stiffening 64, 66, 109, 110, 396
 - stiffening coefficient 65
 - tie 98, 136, 260
 - time
 - clock 11
 - loading 11
 - Timoshenko beam 68, 84, 85, 112
 - element 86, 93, 340
 - enhanced element 88
 - traction-separation relation 204, 219, 236, 244, 263
 - transfer length 396, 399
 - triaxial cell 168
- u**
- uncertainty
 - aleatoric 353
 - epistemic 353
 - model 273, 322, 351, 352, 354
- v**
- validation 9
 - variable 8
 - virtual work principle 11, 21, 84, 194

visco-elasticity 47
viscosity 47
 artificial 208, 269, 382
Voigt notation
 strain 155
 stress 156

y
yield function 174, 177, 180
 Drucker–Prager 178
 Mises 175
 Mohr–Coulomb 179
yield line method 323, 325, 326

