Subject Index

A	stacking sequence effects and delamination, 249
Advanced composites	Compression fatigue, 3-D braided carbon/epoxy
differently oriented plies, graphite/epoxy	composites, 368
composites, 132	Compression tension, stacking sequence effects
random-damage finite element, 232	and delamination, 249
ASTM D 695, 317	Compression testing, impregnated tows, 317
	Crack growth, mode I interlaminar, 19
	Cracking, transverse, energy release rate, shear
В	deformation analysis, 215
	Crack pinning, phenolic bead-filled epoxy, 38
Braided composites, 368	Crack propagation, differently oriented plies,
	graphite/epoxy composites, 132
C	Crack tip element approach, energy release rate
Č	prediction, edge delamination, 155
Carbon bead, reinforced glass fiber laminates, 38	CRFP, nonpenetrating impact behavior, 333
Carbon/bismaleimeide-epoxy systems, marine	Cutout
environmental effects, 283	interface-related fracture, 176
Carbon/epoxy composites	multidirectional composite plates, 186
delamination under cyclic Mode II loading, 61	manual composite places, 100
interlayer toughened, Mode I and II	D
delamination growth, 19	~
marine environmental effects, 283	Damage
stitch-reinforced, 351	arrest, graphite/epoxy tape cylinders, 407
3-D braided, impact and fatigue resistance, 368	growth, polymer matrix composites, 351
Carbon fiber, compression testing, 317	matrix cracking-induced accumulated, 186
Carbon-fiber epoxy composites, delamination, 486	mechanism, 3-D braided carbon/epoxy
Carbon fiber reinforced epoxy, Mode III	composites, 368
delamination, 85	progress, post-impact, 351
Carbon nonwoven mat interleaves, delamination	propagation, graphite/epoxy tape cylinders, 40%
resistance, 124	random, finite element, 232
Combined loading, glass/epoxy laminates, 440	resistance, laminated composite plates, 389
Composite materials	tolerance, graphite/epoxy tape cylinders, 407
carbon/epoxy laminates, 61	Degradation, in marine environments, 283
carbon fiber-reinforced epoxy, 85	Delamination
glass/epoxy, 440	carbon/epoxy laminates, under cyclic Mode II
load redistribution, 304	loading, 61
mixed-mode fatigue delamination, 3	criterion, 3
Mode I and II delamination growth, 19	differently oriented plies, graphite/epoxy
plates	composites, 132
impact parameters and response, 389	edge, energy release rate, 155
multidirectional, accumulated damage and	glass/epoxy laminates, 440
failure modeling, 186	growth and stacking sequence, graphite/epoxy
transverse cracking, 215	laminates, 249
· ·	

Delamination—continued	tension-tension tests, 486
instrumented impact testing, 333	testing, criterion, 3
Mode I and II growth, 19	Fatigue life, graphite torsion spring, 427
Mode III, 85	Fiber breakage
resistance, carbon nonwoven mat interleaves,	instrumented impact testing, 333
124	multidirectional composite plates, 186
tapered laminates, 467, 486	Fiber-matrix splitting, 176
terminating internal plies under tension fatigue loading, 486	Fiber orientation, graphite/epoxy composites, 132 Fiber tow waves, graphite torsion spring, 427
unidirectional glass/epoxy composite, 100	Fiber-wise splitting, polymer-based composite
Displacement measurements, polymer composite	laminates, 176
laminates, 304	Finite element analysis
Double cantilever beam, 19	multidirectional composite plates, 186
bead-filled epoxies, 38	random-damage, 232
differently oriented plies, graphite/epoxy	3-D, glass/epoxy laminates, 440
composites, 132	tapered laminate, interlaminar stresses, 467
,	Fractography
${f E}$	carbon fiber reinforced epoxy, 85
	unidirectional glass/epoxy composite, 100
Edge delamination	Fracture
energy release rate, 155	carbon fiber reinforced epoxy, 85
stacking sequence effects. 249	criteria, interface-related, 176
Edge displacements, polymer composite	graphite/epoxy tape cylinders, 407
laminates, 304	mixed mode
End notch flexure, 19	differently oriented plies, graphite/epoxy
bead-filled epoxies, 38	composites, 132
carbon/epoxy laminates, 61	interface-related, 176
carbon nonwoven mat interleaves, 124	mode ratios, edge delamination, 155
differently oriented plies, graphite/epoxy	region transition, 19
composites, 132	Fracture intensity factors, fiber-wise splitting, 176
Energy release rate, 19	Fracture mechanics
carbon/epoxy laminates, 61	cyclic Mode II loading, 61 glass fiber laminates, 38
differently oriented plies, graphite/epoxy composites, 132	transverse cracking, 215
prediction, edge delamination, 155	Fracture toughness
shear deformation analysis, transverse cracking,	carbon fiber reinforced epoxy, 85
215	Mode I and II, differently oriented plies,
Epoxy, bead-filled, 38	graphite/epoxy composites, 132
Epoxy-cyanate matrix laminates, graphite fiber	plane-strain, 38
effect on microcracking, 268	•
Epoxy matrix, high-temperature, 427	G
F	GFRP, 38
ľ	Glass/epoxy laminates
Failure	fracture under torsion and combined tension-
initiation, 389	torsion loads, 440
process, random-damage finite element, 232	marine environmental effects, 283
progressive, multidirectional composite plates,	tapered, 467
186	transverse cracking, 215
Fatigue, 19	Glass-fiber epoxy composites, delamination, 486
carbon/epoxy laminates, 61	Glass fiber laminates, interlaminar fracture
compression-dominated loading, graphite/epoxy	toughness, 38
laminates, 249	Glass/PPS systems, marine environmental effects,
polymer composite laminates, 304	283
post-impact response, polymer matrix composites, 351	Graphite-bismaleimide composite plates, response characteristics, 389

Graphite/epoxy composites	plates, impact parameters and response, 389
carbon nonwoven mat interleaves, 124	transverse cracking, 215
delamination and stacking sequence effects, 249	Laminated plate theory, 155
	Large-deformation effects, laminated composite
edge delamination, 155 edge displacements, 304	plates, 389
fracture toughness, differently oriented plies,	Load redistribution, polymer composite laminates, 304
132	Low velocity impact, 3-D braided carbon/epoxy
plates, response characteristics, 389	composites, 368
3-D braided, impact and fatigue resistance, 368	composites, 500
transverse cracking, 215	3.4
tape cylinders, damage tolerance and arrest	M
characteristics, 407	Marine anvironment offeets on polymer metrix
Graphite fibers, effect on microcracking, 268	Marine environment, effects on polymer matrix composites, 283
Graphite torsion spring, 427	Matrix cracks, multidirectional composite plates,
-	186
Н	Microcracking, graphite fiber effect, 268
	Micromechanical simulation, 232
Hybrid composite, glass fiber laminates reinforced	Mixed-mode bending test, 3
with carbon bead, 38	carbon/epoxy laminates, 61
I	Mixed-mode strain energy release rate, 3
•	Mode III, delamination, 85
Impact	Modeling
low-speed, 389	accumulated damage and failure,
nonpenetrating, CRFP, 333	multidirectional composite plates, 186
parameters and laminated composite plate	random-damage finite element, 232
parameters and laminated composite plate response, 389	random-damage finite element, 232
parameters and laminated composite plate response, 389 polymer matrix composites, 351	random-damage finite element, 232
parameters and laminated composite plate response, 389 polymer matrix composites, 351 velocity, 333	P
parameters and laminated composite plate response, 389 polymer matrix composites, 351 velocity, 333 Impregnated tows, compression testing, 317	
parameters and laminated composite plate response, 389 polymer matrix composites, 351 velocity, 333 Impregnated tows, compression testing, 317 In-plane loads, multidirectional composite plates,	Paris law, carbon/epoxy laminate delamination,
parameters and laminated composite plate response, 389 polymer matrix composites, 351 velocity, 333 Impregnated tows, compression testing, 317 In-plane loads, multidirectional composite plates, 186	P Paris law, carbon/epoxy laminate delamination, 61 Plastic deformation, phenolic bead-filled epoxy,
parameters and laminated composite plate response, 389 polymer matrix composites, 351 velocity, 333 Impregnated tows, compression testing, 317 In-plane loads, multidirectional composite plates, 186 Instrumented impact testing, 333	P Paris law, carbon/epoxy laminate delamination, 61 Plastic deformation, phenolic bead-filled epoxy, 38
parameters and laminated composite plate response, 389 polymer matrix composites, 351 velocity, 333 Impregnated tows, compression testing, 317 In-plane loads, multidirectional composite plates, 186 Instrumented impact testing, 333 Interfacial degradation, polymer matrix	P Paris law, carbon/epoxy laminate delamination, 61 Plastic deformation, phenolic bead-filled epoxy, 38 Plate size effect, laminated composite plates, 389
parameters and laminated composite plate response, 389 polymer matrix composites, 351 velocity, 333 Impregnated tows, compression testing, 317 In-plane loads, multidirectional composite plates, 186 Instrumented impact testing, 333 Interfacial degradation, polymer matrix composites, 283	P Paris law, carbon/epoxy laminate delamination, 61 Plastic deformation, phenolic bead-filled epoxy, 38 Plate size effect, laminated composite plates, 389 Ply drop, tapered composites, 486
parameters and laminated composite plate response, 389 polymer matrix composites, 351 velocity, 333 Impregnated tows, compression testing, 317 In-plane loads, multidirectional composite plates, 186 Instrumented impact testing, 333 Interfacial degradation, polymer matrix composites, 283 Interlaminar fracture, glass/epoxy laminates, 440	P Paris law, carbon/epoxy laminate delamination, 61 Plastic deformation, phenolic bead-filled epoxy, 38 Plate size effect, laminated composite plates, 389 Ply drop, tapered composites, 486 effect on interlaminar stresses, 467
parameters and laminated composite plate response, 389 polymer matrix composites, 351 velocity, 333 Impregnated tows, compression testing, 317 In-plane loads, multidirectional composite plates, 186 Instrumented impact testing, 333 Interfacial degradation, polymer matrix composites, 283 Interlaminar fracture, glass/epoxy laminates, 440 Interlaminar fracture toughness, 3	P Paris law, carbon/epoxy laminate delamination, 61 Plastic deformation, phenolic bead-filled epoxy, 38 Plate size effect, laminated composite plates, 389 Ply drop, tapered composites, 486 effect on interlaminar stresses, 467 Polymer composite laminates
parameters and laminated composite plate response, 389 polymer matrix composites, 351 velocity, 333 Impregnated tows, compression testing, 317 In-plane loads, multidirectional composite plates, 186 Instrumented impact testing, 333 Interfacial degradation, polymer matrix composites, 283 Interlaminar fracture, glass/epoxy laminates, 440 Interlaminar fracture toughness, 3 glass fiber laminates, 38	P Paris law, carbon/epoxy laminate delamination, 61 Plastic deformation, phenolic bead-filled epoxy, 38 Plate size effect, laminated composite plates, 389 Ply drop, tapered composites, 486 effect on interlaminar stresses, 467 Polymer composite laminates fiber-wise splitting, 176
parameters and laminated composite plate response, 389 polymer matrix composites, 351 velocity, 333 Impregnated tows, compression testing, 317 In-plane loads, multidirectional composite plates, 186 Instrumented impact testing, 333 Interfacial degradation, polymer matrix composites, 283 Interlaminar fracture, glass/epoxy laminates, 440 Interlaminar fracture toughness, 3 glass fiber laminates, 38 interlayer toughened carbon/epoxy composite	P Paris law, carbon/epoxy laminate delamination, 61 Plastic deformation, phenolic bead-filled epoxy, 38 Plate size effect, laminated composite plates, 389 Ply drop, tapered composites, 486 effect on interlaminar stresses, 467 Polymer composite laminates fiber-wise splitting, 176 load redistribution, 304
parameters and laminated composite plate response, 389 polymer matrix composites, 351 velocity, 333 Impregnated tows, compression testing, 317 In-plane loads, multidirectional composite plates, 186 Instrumented impact testing, 333 Interfacial degradation, polymer matrix composites, 283 Interlaminar fracture, glass/epoxy laminates, 440 Interlaminar fracture toughness, 3 glass fiber laminates, 38 interlayer toughened carbon/epoxy composite system, 19	P Paris law, carbon/epoxy laminate delamination, 61 Plastic deformation, phenolic bead-filled epoxy, 38 Plate size effect, laminated composite plates, 389 Ply drop, tapered composites, 486 effect on interlaminar stresses, 467 Polymer composite laminates fiber-wise splitting, 176 load redistribution, 304 Polymer matrix composites
parameters and laminated composite plate response, 389 polymer matrix composites, 351 velocity, 333 Impregnated tows, compression testing, 317 In-plane loads, multidirectional composite plates, 186 Instrumented impact testing, 333 Interfacial degradation, polymer matrix composites, 283 Interlaminar fracture, glass/epoxy laminates, 440 Interlaminar fracture toughness, 3 glass fiber laminates, 38 interlayer toughened carbon/epoxy composite system, 19 unidirectional glass/epoxy composite, 100	P Paris law, carbon/epoxy laminate delamination, 61 Plastic deformation, phenolic bead-filled epoxy, 38 Plate size effect, laminated composite plates, 389 Ply drop, tapered composites, 486 effect on interlaminar stresses, 467 Polymer composite laminates fiber-wise splitting, 176 load redistribution, 304 Polymer matrix composites carbon nonwoven mat interleaves, 124
parameters and laminated composite plate response, 389 polymer matrix composites, 351 velocity, 333 Impregnated tows, compression testing, 317 In-plane loads, multidirectional composite plates, 186 Instrumented impact testing, 333 Interfacial degradation, polymer matrix composites, 283 Interlaminar fracture, glass/epoxy laminates, 440 Interlaminar fracture toughness, 3 glass fiber laminates, 38 interlayer toughened carbon/epoxy composite system, 19 unidirectional glass/epoxy composite, 100 Interlaminar stresses, tapered laminates, ply drop,	Paris law, carbon/epoxy laminate delamination, 61 Plastic deformation, phenolic bead-filled epoxy, 38 Plate size effect, laminated composite plates, 389 Ply drop, tapered composites, 486 effect on interlaminar stresses, 467 Polymer composite laminates fiber-wise splitting, 176 load redistribution, 304 Polymer matrix composites carbon nonwoven mat interleaves, 124 marine environmental effects, 283
parameters and laminated composite plate response, 389 polymer matrix composites, 351 velocity, 333 Impregnated tows, compression testing, 317 In-plane loads, multidirectional composite plates, 186 Instrumented impact testing, 333 Interfacial degradation, polymer matrix composites, 283 Interlaminar fracture, glass/epoxy laminates, 440 Interlaminar fracture toughness, 3 glass fiber laminates, 38 interlayer toughened carbon/epoxy composite system, 19 unidirectional glass/epoxy composite, 100 Interlaminar stresses, tapered laminates, ply drop, 467	Paris law, carbon/epoxy laminate delamination, 61 Plastic deformation, phenolic bead-filled epoxy, 38 Plate size effect, laminated composite plates, 389 Ply drop, tapered composites, 486 effect on interlaminar stresses, 467 Polymer composite laminates fiber-wise splitting, 176 load redistribution, 304 Polymer matrix composites carbon nonwoven mat interleaves, 124 marine environmental effects, 283 microcracking and graphite fiber properties,
parameters and laminated composite plate response, 389 polymer matrix composites, 351 velocity, 333 Impregnated tows, compression testing, 317 In-plane loads, multidirectional composite plates, 186 Instrumented impact testing, 333 Interfacial degradation, polymer matrix composites, 283 Interlaminar fracture, glass/epoxy laminates, 440 Interlaminar fracture toughness, 3 glass fiber laminates, 38 interlayer toughened carbon/epoxy composite system, 19 unidirectional glass/epoxy composite, 100 Interlaminar stresses, tapered laminates, ply drop, 467 Interlayer toughened composites, 19	Paris law, carbon/epoxy laminate delamination, 61 Plastic deformation, phenolic bead-filled epoxy, 38 Plate size effect, laminated composite plates, 389 Ply drop, tapered composites, 486 effect on interlaminar stresses, 467 Polymer composite laminates fiber-wise splitting, 176 load redistribution, 304 Polymer matrix composites carbon nonwoven mat interleaves, 124 marine environmental effects, 283 microcracking and graphite fiber properties, 268
parameters and laminated composite plate response, 389 polymer matrix composites, 351 velocity, 333 Impregnated tows, compression testing, 317 In-plane loads, multidirectional composite plates, 186 Instrumented impact testing, 333 Interfacial degradation, polymer matrix composites, 283 Interlaminar fracture, glass/epoxy laminates, 440 Interlaminar fracture toughness, 3 glass fiber laminates, 38 interlayer toughened carbon/epoxy composite system, 19 unidirectional glass/epoxy composite, 100 Interlaminar stresses, tapered laminates, ply drop, 467	Paris law, carbon/epoxy laminate delamination, 61 Plastic deformation, phenolic bead-filled epoxy, 38 Plate size effect, laminated composite plates, 389 Ply drop, tapered composites, 486 effect on interlaminar stresses, 467 Polymer composite laminates fiber-wise splitting, 176 load redistribution, 304 Polymer matrix composites carbon nonwoven mat interleaves, 124 marine environmental effects, 283 microcracking and graphite fiber properties,
parameters and laminated composite plate response, 389 polymer matrix composites, 351 velocity, 333 Impregnated tows, compression testing, 317 In-plane loads, multidirectional composite plates, 186 Instrumented impact testing, 333 Interfacial degradation, polymer matrix composites, 283 Interlaminar fracture, glass/epoxy laminates, 440 Interlaminar fracture toughness, 3 glass fiber laminates, 38 interlayer toughened carbon/epoxy composite system, 19 unidirectional glass/epoxy composite, 100 Interlaminar stresses, tapered laminates, ply drop, 467 Interlayer toughened composites, 19 Interleaved composites, carbon nonwoven mat, 124	Paris law, carbon/epoxy laminate delamination, 61 Plastic deformation, phenolic bead-filled epoxy, 38 Plate size effect, laminated composite plates, 389 Ply drop, tapered composites, 486 effect on interlaminar stresses, 467 Polymer composite laminates fiber-wise splitting, 176 load redistribution, 304 Polymer matrix composites carbon nonwoven mat interleaves, 124 marine environmental effects, 283 microcracking and graphite fiber properties, 268 post-impact fatigue response, 351
parameters and laminated composite plate response, 389 polymer matrix composites, 351 velocity, 333 Impregnated tows, compression testing, 317 In-plane loads, multidirectional composite plates, 186 Instrumented impact testing, 333 Interfacial degradation, polymer matrix composites, 283 Interlaminar fracture, glass/epoxy laminates, 440 Interlaminar fracture toughness, 3 glass fiber laminates, 38 interlayer toughened carbon/epoxy composite system, 19 unidirectional glass/epoxy composite, 100 Interlaminar stresses, tapered laminates, ply drop, 467 Interlayer toughened composites, 19 Interleaved composites, carbon nonwoven mat,	Paris law, carbon/epoxy laminate delamination, 61 Plastic deformation, phenolic bead-filled epoxy, 38 Plate size effect, laminated composite plates, 389 Ply drop, tapered composites, 486 effect on interlaminar stresses, 467 Polymer composite laminates fiber-wise splitting, 176 load redistribution, 304 Polymer matrix composites carbon nonwoven mat interleaves, 124 marine environmental effects, 283 microcracking and graphite fiber properties, 268 post-impact fatigue response, 351
parameters and laminated composite plate response, 389 polymer matrix composites, 351 velocity, 333 Impregnated tows, compression testing, 317 In-plane loads, multidirectional composite plates, 186 Instrumented impact testing, 333 Interfacial degradation, polymer matrix composites, 283 Interlaminar fracture, glass/epoxy laminates, 440 Interlaminar fracture toughness, 3 glass fiber laminates, 38 interlayer toughened carbon/epoxy composite system, 19 unidirectional glass/epoxy composite, 100 Interlaminar stresses, tapered laminates, ply drop, 467 Interlayer toughened composites, 19 Interleaved composites, carbon nonwoven mat, 124	Paris law, carbon/epoxy laminate delamination, 61 Plastic deformation, phenolic bead-filled epoxy, 38 Plate size effect, laminated composite plates, 389 Ply drop, tapered composites, 486 effect on interlaminar stresses, 467 Polymer composite laminates fiber-wise splitting, 176 load redistribution, 304 Polymer matrix composites carbon nonwoven mat interleaves, 124 marine environmental effects, 283 microcracking and graphite fiber properties, 268 post-impact fatigue response, 351 PPS, marine environmental effects, 283

L

Laminated composites, see Composite materials

mixed-mode fatigue delamination, 3

R

Resin pockets, tapered laminates, 467 Resin transfer molding process, 368

S

Scanning electron microscopy, polymer matrix composites, 283

Shear cracks, through-the-thickness, glass/epoxy laminates, 440

Shear deformation analysis, energy release rate, transverse cracking, 215

Shear hackles, carbon fiber reinforced epoxy, 85 Simulation, advanced composite failure, 232

Space structures, graphite-fiber-reinforced polymer composites, 268

Split cantilever beam, Mode III delamination, 85 Splitting, graphite/epoxy tape cylinders, 407

Stacking sequence, effects and delamination growth, graphite/epoxy laminates, 249 Stiffening strips, graphite/epoxy tape cylinders,

407 Stiffness, 3-D braided carbon/epoxy composites,

Stitching, polymer matrix composites, 351 Strain energy release rate

carbon/epoxy laminates, 61 fiber-wise splitting, 176

glass and carbon epoxy composites, 486 unidirectional glass/epoxy composite, 100

Strength

degradation, 3-D braided carbon/epoxy composites, 368 graphite torsion spring, 427 Stress, interlaminar, ply-drop geometry, 467 Structural scaling, graphite/epoxy tape cylinders, 407

T

Tapered composites, delamination, 467, 486 Tension-compression fatigue, polymer matrix composites, 351 Tension fatigue

loading, terminating internal plies, 486
3-D braided carbon/epoxy composites, 368
Tension-tension fatigue loading, polymer
composite laminates, 304

Tension-torsion loads, glass/epoxy laminate fracture, 440

Terminating plies, tapered composites, 486
Thermal cycling, epoxy-cyanate matrix laminates,
268

Thermoplastic matrix composite, 19
Thermoset matrix composite, 19
Torsion, glass/epoxy laminate fracture, 440
Toughness, differently oriented plies, graphite/
epoxy composites, 132

Tows, impregnated, compression testing, 317
Tow waves, graphite torsion spring, 427
Translaminar fracture, graphite torsion spring, 427
Transverse cracking, energy release rate, shear
deformation analysis, 215

Transverse strength, polymer matrix composites, 283

U

Unidirectional glass/epoxy composite, mixed mode interlaminar fracture toughness, 100 Unidirectional layup, carbon/epoxy laminates, 61

V

Voids, tapered laminates, 467

W

Water absorption, polymer matrix composites, 283