

PLY DATA

PLY DATABASE CONTROL CARDS

CARDS 1 and 2

CARD 1 Ply Identification

Columns	Item	Format	Name	version/option
1-8	Keyword PLY ___/___	A8		
9-16	Ply entity identification number	I8	IDPLY	
17-24	Ply model identification flag = 0: Unidirectional composite bi-phase ply model = 1: Unidirectional composite global ply model = 2: Isotropic elastic-plastic damaging ply model (after Material Type 105) = 3: not applicable = 4: not applicable = 5: not applicable = 6: Fabric composite bi-phase ply model = 7: Fabric composite global ply model	I8	ITYP	
25-40	Mass density of ply material	E16.0	ρ	
41-48	Flag for input of ply failure criterion = 0: none = 1: Ply failure criterion has to be specified on Cards 14 and following (Cards 16 and following for ply type 6)	I8	IFAIL_INP	
49-56	Strain rate model to be used (only available with ply type 2) = 0: Strain rates switched off (default) = 1: Cowper-Symonds = 2: Johnson-Cook = 3: Modified Jones = 4: Left shifted (*) = 5: Krupkowsky (*)	I8	ISTRAT	

(*): these strain rate models are applicable only for Krupkowsky stress-strain hardening

Units

- The real variables provided on Card 1 have the following units.

Variable	ρ
Units	mass/[volume]

CARD 2 Title

Columns	Item	Format	Name	version/option
1-4	NAME	A4		
5-80	Material identification title	A76	TITLE	

Notes:

- Proceed to subsections, based on the type of ply model selected on Card 1, as follows.
 - ITYP=0: Unidirectional composite bi-phase ply model (solids and shells)
 - ITYP=1: Unidirectional composite global ply model (shells)
 - ITYP=2: Isotropic elastic-plastic damaging ply model (shells)
 - ITYP=6: Fabric composite bi-phase ply model (shells)
 - ITYP=7: Fabric composite global ply model (shells).
- Parameters MATYP (Material Control Card 1) and ITYP (Ply Identification Card 1) can combine as follows.

Table (a): Parameters MATYP and ITYP

MATYP	ITYP=	0	1	2	6	7	Remarks
30, 31		x					linear and nonlinear fiber solids
130		x					standard multilayered shells
131		x	x	x		x	advanced multilayered shells
132					x	x	multilayered shells with fabrics

- Ply type 0 and 6 correspond to **heterogeneous** plies with distinct matrix and fiber phases ("bi-phase").
- Ply type 1 and 7 treat the heterogeneity of fiber and matrix composite plies by recognizing a fiber-matrix interface damage and a fiber rupture strain.
- Ply type 2 corresponds to **homogeneous** ply without a fiber phase. Its material model is derived from standard shell material type 5.
- For further information, see also the **Ply DataBase Control Cards** sub-section of the Solver Notes Manual.

UNIDIRECTIONAL COMPOSITE BI-PHASE PLY MODEL (ITYP=0)

CARDS 3 to 13

Basic Bi-Phase Material Data Input: Tensile Matrix Properties

CARD 3 Tensile Matrix or Unidirectional Ply Elastic Properties-1

Columns	Item	Format	Name	version/option
1-10	Tensile matrix Young's modulus in 1-direction	E10.0	E11	
11-20	Tensile matrix Young's modulus in 2-direction	E10.0	E22	
21-30	Tensile matrix Young's modulus in 3-direction	E10.0	E33	

CARD 4 Tensile Matrix or Unidirectional Ply Elastic Properties-2

Columns	Item	Format	Name	version/option
1-10	Tensile matrix shear modulus in 1,2-plane	E10.0	G12	
11-20	Tensile matrix shear modulus in 2,3-plane	E10.0	G23	
21-30	Tensile matrix shear modulus in 1,3-plane	E10.0	G13	
31-40	Tensile matrix Poisson's ratio in 1,2-plane	E10.0	v12	
41-50	Tensile matrix Poisson's ratio in 2,3-plane	E10.0	v23	
51-60	Tensile matrix Poisson's ratio in 1,3-plane	E10.0	v13	

CARD 5 Tensile Matrix Shear Damage Properties

Columns	Item	Format	Name	version/option
1-10	Tensile matrix initial equivalent shear strain	E10.0	ϵ_{si}^{mt}	
11-20	Tensile matrix intermediate equivalent shear strain	E10.0	ϵ_{s1}^{mt}	
21-30	Tensile matrix ultimate equivalent shear strain	E10.0	ϵ_{su}^{mt}	
31-40	Tensile matrix intermediate shear damage	E10.0	d_{s1}^{mt}	
41-50	Tensile matrix ultimate shear damage	E10.0	d_{su}^{mt}	

CARD 6 Tensile Matrix Volume Damage Properties*

Columns	Item	Format	Name	version/option
1-10	Tensile matrix initial volume strain	E10.0	ϵ_{vi}^{mt}	
11-20	Tensile matrix intermediate volume strain	E10.0	ϵ_{v1}^{mt}	
21-30	Tensile matrix ultimate volume strain	E10.0	ϵ_{vu}^{mt}	
31-40	Tensile matrix intermediate volume damage	E10.0	d_{v1}^{mt}	
41-50	Tensile matrix ultimate volume damage	E10.0	d_{vu}^{mt}	

* not active for Material Type 31

Units

· The real variables provided on Cards 3 to 6 have the following units.

Variable	E11, E22, E33 ; G12, G23, G13	v12, v23, v13
Units	[force]/length ²	none

Variable	$\epsilon_{si}^{mt}, \epsilon_{sl}^{mt}, \epsilon_{su}^{mt}; d_{sl}^{mt}, d_{su}^{mt}$	$\epsilon_{vi}^{mt}, \epsilon_{vl}^{mt}, \epsilon_{vu}^{mt}; d_{vl}^{mt}, d_{vu}^{mt}$
Units	none	none

Basic Bi-Phase Material Data Input: Tensile Fiber Properties

CARD 7 Tensile Fiber Properties*

Columns	Item	Format	Name	version/option
1-10	Tensile fiber Young's modulus	E10.0	E^{ft}	
11-20	Tensile fiber volume ratio	E10.0	α^f	
21-30	Tensile fiber initial strain	E10.0	ϵ_i^{ft}	
31-40	Tensile fiber intermediate strain	E10.0	ϵ_1^{ft}	
41-50	Tensile fiber ultimate strain	E10.0	ϵ_u^{ft}	
51-60	Tensile fiber intermediate damage	E10.0	d_1^{ft}	
61-70	Tensile fiber ultimate damage	E10.0	d_u^{ft}	

* not active for material type 31

Units

· The real variables provided on Card 7 have the following , units.

Variable	E^{ft}	$\alpha^f, \epsilon_i^{ft}, \epsilon_1^{ft}, \epsilon_u^{ft}; d_1^{ft}, d_u^{ft}$
Units	[force]/length ²	none

Basic Bi-Phase Material Data Input: Orthotropy and Thickness Properties (Read in Part and Material Sections)

CARD 8 Blank

Basic Bi-Phase Material Data Input: Compressive Matrix Properties

CARD 9 Compressive Matrix or Unidirectional Ply Elastic Properties-1

Columns	Item	Format	Name	version/option
1-10	Compressive matrix Young's modulus in 1-direction	E10.0	E11	
11-20	Compressive matrix Young's modulus in 2-direction	E10.0	E22	
21-30	Compressive matrix Young's modulus in 3-direction	E10.0	E33	

CARD 10 Compressive Matrix or Unidirectional Ply Elastic Properties-2

Columns	Item	Format	Name	version/option
1-10	Compressive matrix shear modulus in 1,2-plane	E10.0	G12	
11-20	Compressive matrix shear modulus in 2,3-plane	E10.0	G23	
21-30	Compressive matrix shear modulus in 1,3-plane	E10.0	G13	
31-40	Compressive matrix Poisson's ratio in 1,2-plane	E10.0	v12	
41-50	Compressive matrix Poisson's ratio in 2,3-plane	E10.0	v23	
51-60	Compressive matrix Poisson's ratio in 1,3-plane	E10.0	v13	

CARD 11 Compressive Matrix Shear Damage Properties

Columns	Item	Format	Name	version/option
1-10	Compressive matrix initial equivalent shear strain	E10.0	ϵ_{si}^{mc}	
11-20	Compressive matrix intermediate equivalent shear strain	E10.0	ϵ_{sI}^{mc}	
21-30	Compressive matrix ultimate equivalent shear strain	E10.0	ϵ_{su}^{mc}	
31-40	Compressive matrix intermediate shear damage	E10.0	d_{sI}^{mc}	
41-50	Compressive matrix ultimate shear damage	E10.0	d_{su}^{mc}	

CARD 12 Compressive Matrix Volume Damage Properties*

Columns	Item	Format	Name	version/option
1-10	Compressive matrix initial volume strain	E10.0	ϵ_{vi}^{mc}	
11-20	Compressive matrix intermediate volume strain	E10.0	ϵ_{vI}^{mc}	
21-30	Compressive matrix ultimate volume strain	E10.0	ϵ_{vu}^{mc}	
31-40	Compressive matrix intermediate volume damage	E10.0	d_{vI}^{mc}	
41-50	Compressive matrix ultimate volume damage	E10.0	d_{vu}^{mc}	

* not active for material type 31

PLY DATA

Units

- The real variables provided on Cards 9 to 12 have the following units.

Variable	E11, E22, E33 ; G12, G23, G13	v12, v23, v13
Units	[force]/length ²	none

Variable	$\epsilon_{si}^{mc}, \epsilon_{sl}^{mc}, \epsilon_{su}^{mc}; d_{sl}^{mc}, d_{su}^{mc}$	$\epsilon_{vi}^{mc}, \epsilon_{vl}^{mc}, \epsilon_{vu}^{mc}; d_{vl}^{mc}, d_{vu}^{mc}$
Units	none	none

Basic Bi-Phase Material Data Input: Compressive Fiber Properties

CARD 13 Compressive Fiber Properties*

Columns	Item	Format	Name	version/option
1-10	Compressive fiber Young's modulus	E10.0	E^{fc}	
11-20	Compressive fiber volume ratio	E10.0	α^f	
21-30	Compressive fiber initial strain	E10.0	ϵ_i^{fc}	
31-40	Compressive fiber intermediate strain	E10.0	ϵ_l^{fc}	
41-50	Compressive fiber ultimate strain	E10.0	ϵ_u^{fc}	
51-60	Compressive fiber intermediate damage	E10.0	d_l^{fc}	
61-70	Compressive fiber ultimate damage	E10.0	d_u^{fc}	

* not active for material type 31

Units

- The real variables provided on Card 13 have the following units.

Variable	E^{fc}	$\alpha^f, \epsilon_i^{fc}, \epsilon_l^{fc}, \epsilon_u^{fc}; d_l^{fc}, d_u^{fc}$
Units	[force]/length ²	none

CARDS IBEG to IBEG+2

Bi-phase Failure Criteria Input

Provide Cards IBEG to IBEG+2 only if IFAIL_INP=1 on Card 1.

CARD IBEG Ply failure type

Columns	Item	Format	Name	version/option
1-10	Flag to trigger type of failure treatment: = 0 : Failure computed for output only (stress tensor not scaled, damage and elimination not active) = 1 : Failure computed and imposed (stress tensor is scaled down, damage and elimination is active)	I10	IFAIL_DAM	
11-20	Type of ply failure model: = 0 : Equivalent shear strain ($\epsilon_s > \epsilon_s^{\text{lim}}$). available for ply type: 0, 1, 2, 3, 4, 6, 7 = 1 : Tsai Wu criterion ($f > 1$). available for ply type: 0, 1, 6, 7 = 2 : Hoffmann criterion ($f > 1$). available for ply type: 0, 1, 6, 7 = 3 : Tsai Hill criterion ($f > 1$). available for ply type: 0, 1, 6, 7 = 4 : Modified Puck criterion ($f > 1$) available for ply type: 0, 1, 6, 7 = 5 : Maximum stress criterion ($f > 1$) available for ply type: 0, 1, 6, 7 = 6 : Maximum strain criterion ($f > 1$). available for ply type: 0, 1, 6, 7 = 7 : 3-Invariants criterion ($f > 1$). available for ply type: 0, 1, 2, 3, 4, 6, 7 = 8 : User defined criterion. available for ply type: 0, 1, 2, 3, 4, 6, 7 = 9 : Equivalent shear stress ($\sigma_s > \sigma_s^{\text{lim}}$). available for ply type: 0, 1, 2, 3, 4, 6, 7	I10	IFAIL_TYP	v2006
21-30	Number of history variables for user defined criterion	I10	IUSER_ALO	
31-80	Blank	50X		

PLY DATA

Equivalent shear strain: IFAIL_TYP = 0

CARD IBEG+1

Columns	Item	Format	Name	version/option
1-10	Shear strain limit	E10.0	ϵ_s^{lim}	
11-80	Blank	70X		

CARD IBEG+2

Columns	Item	Format	Name	version/option
1-80	Blank	80X		

Stress tensor based models: IFAIL_TYP = 1, 2, 3, 4, 5

CARD IBEG+1 Tensile Strength and Positive Shear

Columns	Item	Format	Name	version/option
1-10	Tensile strength in 1-direction	E10.0	σ_{11u}^t	
11-20	Tensile strength in 2-direction	E10.0	σ_{22u}^t	
21-30	Tensile strength in 3-direction	E10.0	σ_{33u}^t	
31-40	Positive shear strength in 12-plane	E10.0	τ_{12u}^p	
41-50	Positive shear strength in 23-plane	E10.0	τ_{23u}^p	
51-60	Positive shear strength in 13-plane	E10.0	τ_{13u}^p	
61-70	Parameter k in $F12 = k\sqrt{F11 \times F22}$ for Tsai-Wu criterion (default : -0.5)	E10.0	k	

CARD IBEG+2 Compressive Strength and Negative Shear

Columns	Item	Format	Name	version/option
1-10	Compressive strength in 1-direction	E10.0	σ_{11u}^c	
11-20	Compressive strength in 2-direction	E10.0	σ_{22u}^c	
21-30	Compressive strength in 3-direction	E10.0	σ_{33u}^c	
31-40	Negative shear strength in 12-plane	E10.0	τ_{12u}^n	
41-50	Negative shear strength in 23-plane	E10.0	τ_{23u}^n	
51-60	Negative shear strength in 13-plane	E10.0	τ_{13u}^n	

Maximum strain criterion: IFAIL_TYP = 6

CARD IBEG+1 Tensile Ultimate Strain and Positive Shear

Columns	Item	Format	Name	version/option
1-10	Tensile ultimate strain in 1-direction	E10.0	ϵ_{11u}^t	
11-20	Tensile ultimate strain in 2-direction	E10.0	ϵ_{22u}^t	
21-30	Tensile ultimate strain in 3-direction	E10.0	ϵ_{33u}^t	
31-40	Positive ultimate shear strain in 12-plane	E10.0	ϵ_{12u}^p	
41-50	Positive ultimate shear strain in 23-plane	E10.0	ϵ_{23u}^p	
51-60	Positive ultimate shear strain in 13-plane	E10.0	ϵ_{13u}^p	

CARD IBEG+2 Compressive Ultimate Strain and Negative Shear

Columns	Item	Format	Name	version/option
1-10	Compressive ultimate strain in 1-direction	E10.0	ϵ_{11u}^c	
11-20	Compressive ultimate strain in 2-direction	E10.0	ϵ_{22u}^c	
21-30	Compressive ultimate strain in 3-direction	E10.0	ϵ_{33u}^c	
31-40	Negative ultimate shear strain in 12-plane	E10.0	ϵ_{12u}^n	
41-50	Negative ultimate shear strain in 23-plane	E10.0	ϵ_{23u}^n	
51-60	Negative ultimate shear strain in 13-plane	E10.0	ϵ_{13u}^n	

3 invariants criterion: IFAIL_TYP = 7

CARD IBEG+1

Columns	Item	Format	Name	version/option
1-10	Biaxial sensitivity factor	E10.0	θ	
11-20	Equivalent strain limit	E10.0	ϵ_s^{lim}	
21-80	Blank	60X		

CARD IBEG+2

Columns	Item	Format	Name	version/option
1-80	Blank	80X		

PLY DATA

User defined criterion: IFAIL_TYP = 8

CARD IBEG+1

Columns	Item	Format	Name	version/option
1-10	User parameter 1	E10.0		
11-20	User parameter 2	E10.0		
21-30	User parameter 3	E10.0		
31-40	User parameter 4	E10.0		
41-50	User parameter 5	E10.0		
51-60	User parameter 6	E10.0		
61-70	User parameter 7	E10.0		
71-80	User parameter 8	E10.0		

CARD IBEG+2

Columns	Item	Format	Name	version/option
1-10	User parameter 9	E10.0		
11-20	User parameter 10	E10.0		
21-30	User parameter 11	E10.0		
31-40	User parameter 12	E10.0		
41-50	User parameter 13	E10.0		
51-60	User parameter 14	E10.0		
61-70	User parameter 15	E10.0		
71-80	User parameter 16	E10.0		

Equivalent shear strain: IFAIL_TYP = 9

CARD IBEG+1

Columns	Item	Format	Name	version/option
1-10	Equivalent stress limit σ_s^{lim}	E10.0		v2006
11-80	Blank	70X		v2006

CARD IBEG+2

Columns	Item	Format	Name	version/option
1-80	Blank	80X		v2006

Units

- The real variables provided on Cards IBEG+1 to IBEG+2 have the following units.

Variable	all "strength" variables ("σ", "τ")	K, θ	all "strain" variables ("ε")
Units	[stress]	none	none

Notes for Ply Model $ITYP=0$:

- Ply Model $ITYP=0$ corresponds to continuous fiber reinforced composite materials with a heterogeneous (bi-phase) description of the matrix and the fiber phases.
- For further information, see also the **Ply Model $ITYP=0$** sub-section of the Solver Notes Manual.