MATERIAL TYPES 130, 131, 132 (Multilayered Shell Elements)

CARD 3 Stackup Data

Columns	Item	Format	Name	*version/option*
1-10	Stiffness proportional damping ratio ($0 < \xi < 1$)	E10.0	ξ	
11-20	Damping target frequency (units : time^{-1}) = 0: element frequency is considered (generally very high) > 0: frequency at which response is damped out with ξ	E10.0	f_o	
21-25	Number of plies (< 48)	I5	NOPLY	
26-40	Blank	15X		
41-50	Membrane hourglass coefficient (default: 0.01)	E10.0	HGM	
51-60	Out of plane hourglass coefficient (w mode) (default: 0.01)	E10.0	HGW	
61-70	Rotation hourglass coefficient (q mode) (default: 0.01)	E10.0	HGQ	
71-80	Transverse shear correction factor	E10.0	A_s	

Units

· The real variables provided on Card 3 have the following units.

Variable	ξ	f_o	NOPLY, HGM, HGW, HGQ, A_s
Units	none	time^{-1}	none

CARD 4, 5, …+(NOPLY+3): Composite Ply Data Base Identification

Columns	Item	Format	Name	*version/option*
1-10	Ply data base identification number of ply	I10	IDPLY	
11-20	Ply thickness	E10.0	THKPL	
21-30	Angle to define ply orientation from reference direction (in degree, reference direction is given in PART section)	E10.0	ANGPL	

Units

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

Variable	NOPLY	THKPL	ANGPL
Units	none	length	degree

SHELL
MATERIALS

CARD 4 + NOPLY: Element Elimination

Columns	Item	Format	Name	version/option
1-10	Blank	10X		
11-15	Minimum allowed number of cycles for total damage to reach the value of 1.0 = 0: one cycle	I5	NMIN	
16-20	Blank	5X		
	Parameters for GRUC output:			
21-30	Sub-keyword for selecting *one* Generic Relative User Criterion (GRUC) output from the following menu: **DMG**: for maximum damage **THIC**: for thickness	A10		
31-40	GRUC value, default rule is: **DMG** = 1. **THIC**= element initial thickness	E10.0		
41-45	Flag to control element elimination based on ply failure = 0 : no element elimination = 1: element elimination if one ply reaches failure criterion = 2: element elimination if all plies reach failure criterion. Behavior also depends on IFAIL_DAM in ply cards. = 3: element elimination if neutral axis ply or plies reach failure criterion = 4: element elimination if upper or lower surface ply reach failure criterion = 5: element elimination if a specified ratio of plies fail	I5	IFAIL	
46-50	Blank	5X		
51-60	Ratio of plies failed to trigger element elimination (0<ERATIO<1)	E10.0	ERATIO	
61-80	Blank	20X		

Units

· *The real variables provided on Card 4 above have the following units.*

Variable	σ_s^{lim}	ε_s^{lim}
Units	[stress]	none

SHELL MATERIALS
Material Types 130, 131, 132
(Multilayered Shell Elements)

CARD 5+NOPLY: Auxiliary Plot Variable Definition-1

Columns	Item	Format	Name	*version/option*
1-5	Ply number	I5		
6-10	1-st reference number of auxiliary variable saved for plot	I5		
11-15	Ply number	I5		
16-20	2-nd reference number of auxiliary variable saved for plot	I5		
:	:			
71-75	Ply number	I5		
76-80	8-th reference number of auxiliary variable saved for plot	I5		

CARD 6 + NOPLY: Auxiliary Plot Variable Definition – 2

Columns	Item	Format	Name	*version/option*
1-5	Ply number	I5		
6-10	9-th reference number of auxiliary variable saved for plot	I5		
11-15	Ply number	I5		
16-20	10-th reference number of auxiliary variable saved for plot	I5		
:	:			
71-75	Ply number	I5		
76-80	16-th reference number of auxiliary variable saved for plot	I5		

CARD 7 +NOPLY: Auxiliary Plot Variable Definition – 3

Columns	Item	Format	Name	*version/option*
1-5	Ply number	I5		
6-10	17-th reference number of auxiliary variable saved for plot	I5		
11-15	Ply number	I5		
16-20	18-th reference number of auxiliary variable saved for plot	I5		
:	:			
71-75	Ply number	I5		
76-80	24-th reference number of auxiliary variable saved for plot	I5		

SHELL
MATERIALS

SHELL MATERIALS
Material Types 130, 131, 132
(Multilayered Shell Elements)

CARD 8 + NOPLY: Auxiliary Plot Variable Definition – 4

Columns	Item	Format	Name	version/option
1-5	Ply number	I5		
6-10	25-th reference number of auxiliary variable saved for plot	I5		
11-15	Ply number	I5		
16-20	26-th reference number of auxiliary variable saved for plot	I5		
:	:			
71-75	Ply number	I5		
76-80	32-nd reference number of auxiliary variable saved for plot	I5		

CARD 9 + NOPLY: Auxiliary Plot Variable Definition – 5

Columns	Item	Format	Name	version/option
1-5	Ply number	I5		
6-10	33-rd reference number of auxiliary variable saved for plot	I5		
11-15	Ply number	I5		
16-20	34-th reference number of auxiliary variable saved for plot	I5		
:	:			
71-75	Ply number	I5		
76-80	40-th reference number of auxiliary variable saved for plot	I5		

CARD 10 + NOPLY: Auxiliary Plot Variable Definition – 6

Columns	Item	Format	Name	version/option
1-5	Ply number	I5		
6-10	41-st reference number of auxiliary variable saved for plot	I5		
11-15	Ply number	I5		
16-20	42-nd reference number of auxiliary variable saved for plot	I5		
:	:			
71-75	Ply number	I5		
76-80	48-th reference number of auxiliary variable saved for plot	I5		

**SHELL
MATERIALS**

SHELL MATERIALS
Material Types 130, 131, 132
(Multilayered Shell Elements)

Notes for Material Types 130, 131, 132:

- Material types 130, 131 and 132 correspond to multi-layered shell materials. The plies can be assigned the following material types in the Ply Data Section (parameter `ITYP`)

    · `ITYP=0`: unidirectional composite bi-phase ply model, (material type 130, 131)

    · `ITYP=1`: unidirectional composite global ply model, (material type 131)

    · `ITYP=2`: isotropic elastic-plastic damaging ply model, (material type 131)

    · `ITYP=6`: fabric composite bi-phase ply model.(material type 132, 131)

    · `ITYP=7`: fabric composite global ply model, (material type 131)

- **Auxiliary variables saved for plots.** For material types 130, 131 and 132 the following auxiliary variables can be saved on the plot files, by specifying on Cards 8 to 13 the reference number given in the following table.

Table (a): Auxiliary variables per ply for material types 130, 131 and 132

Reference number	ply type 0 (130,131) ply type 6 (131)	ply type 1 (131)	ply type 2 (131)	ply type 7 (131)	ply type 6 (132)
1	ε_{11}	ε_{11}	ε_{11}	ε_{11}	ε_{11}
2	ε_{22}	ε_{22}	ε_{22}	ε_{22}	ε_{22}
3	ε_{12}	ε_{12}	ε_{12}	ε_{12}	ε_{12}
4	ε_{23}	ε_{23}	ε_{23}	ε_{23}	ε_{23}
5	ε_{13}	ε_{13}	ε_{13}	ε_{13}	ε_{13}
6	σ_{11}	σ_{11}	σ_{11}	σ_{11}	σ_{11}
7	σ_{22}	σ_{22}	σ_{22}	σ_{22}	σ_{22}
8	σ_{12}	σ_{12}	σ_{12}	σ_{12}	σ_{12}
9	σ_{23}	σ_{23}	σ_{23}	σ_{23}	σ_{23}
10	σ_{13}	σ_{13}	σ_{13}	σ_{13}	σ_{13}
11	d^t (total)	d' = shear damage	d = damage	d_{12} (shear)	d^t (total)
12	d_s^t (shear)	d = transverse damage	$\varepsilon^{plastic}$	d_{11} (fiber 1)	d_s^t (shear)
13	d_v^t (volume)	$\varepsilon_{22}^{plastic}$	$\dot{\varepsilon}$	d_{22} (fiber 2)	d_v^t (volume)
14	σ^f	$2\varepsilon_{12}^{plastic}$		$2\varepsilon_{12}^{plastic}$	σ^{f1} (fiber 1)
15	d^f	$\dot{\varepsilon}$		$\dot{\varepsilon}$	d^{f1} (fiber 1)
16					σ^{f2} (fiber 2)
17					d^{f2} (fiber 2)
18					θ
19					ε_{11}^f
20					ε_{22}^f

SHELL MATERIALS

Legend :

In the above table, ε is strain, σ is stress and d is damage, $\dot{\varepsilon}$ is the strain rate and $\varepsilon^{plastic}$ is effective plastic strain. Superscripts t and f refer to total (matrix + fiber) and fiber related quantities and subscripts s and v refer to shear and volumetric quantities, respectively. Subscripts 1, 2, 3 refer to the natural directions of the orthotropic bi-phase material of plies type 0,1,6, 7 (1 = fiber direction ; for the orthotropy axis definition, see the Part Definition Cards) and to the local element frame for ply type 2. The pair (ply number = n_p, reference number) is specified in the "Auxiliary Plot Variable Definition" Cards of Material Types 130, 131 and 132. θ is the angle in degrees between fibers 1 and 2.

- In PAM-VIEW, the auxiliary variables selected on Material Card 1b for the composite shell elements of the OUTPUT Section can be accessed using the mnemonics AU1, AU2, etc.

- **Extra auxiliary variables saved for plots.** In certain program versions values concerning certain composite failure criteria (Tsay-Wu, Hoffmann, Tsay-Hill, modified Puck, maximum stress, maximum strain) are computed optionally. Such values can be saved for plotting with reference numbers 16 through 33, as indicated in the following table.

Table (b): Further auxiliary variables for materials type 130/131 (for ply types 0,1, 6,7 only)

Reference number	Auxiliary variable
24	Maximal post rupture damage in time over elements
25	Post Damage in ply n_p over time
26	Maximal Failure Criterion in time over elements
27	Failure Criterion in ply n_p over time
28	Maximum of σ_{11} in time over the element
29	Maximum of σ_{22} in time over the element
30	Maximum of σ_{12} in time over the element
31	Maximum of σ_{23} in time over the element
32	Maximum of σ_{13} in time over the element
33	Maximum von Mises stress in time over the element

Legend: In the above table, σ is stress. Superscripts 1, 2, 3 refer to the natural directions of the orthotropic bi-phase material (1 = fiber direction ; for the orthotropy axis definition, see the composite ply data base cards at the end of the material input section). The pair (ply number = n_p, reference number) is specified in the "Auxiliary Plot Variable Definition" Cards of Material Type 130, 131 and 132.

- A GRUC (General Relative User Criterion) variable can be output if specified on the User Selected Shell Plot Output or User Selected Shell Time History Output Keyword Cards (CONTROL SECTION). The variable is defined on element and is non-dimensional. The output corresponds to the ratio 'value computed/value entered'.

- For further information, see also the **Material Types 130 to 132** sub-section of the Solver Notes Manual.

SHELL MATERIALS

SHELL MATERIALS
Material Types 130, 131, 132
(Multilayered Shell Elements)