/	В	С	D	E	F	G	Н	ı	J	K	L	ΜN	
1	744	TIADD	-i	C	T							+	
2			oject (#3) - Analysis of					20201				-	
3	SE-16		ce Structural Analysis, Univers	ity of Califor	nia, San Diego (Cop)	right J.	ь. Kosmatka	, 2020)				-	
5	-	Version:	Winter, 2020 (v2)										
7		roiect Title	03-06-2020 Test Case - 8 ply carl	oon/enovy law	inate offering high ev	tension	and torsion st	iffness/strengt	h. Common in	aircraft wing s	kins.	-	
8	·	roject ritie.	: 03-06-2020 Test Case - 8 ply carbon/epoxy laminate offering high extension and torsion stiffness/strength. Common in aircraft wing skins.										
9		Variable	Description	Value	Units					ference			
10		iInput	Input Units	1	1 = US				US	SI			
11		iOutput	Output Units	1	1 = US, 2 = SI			F	10 ³ lb/in ²	MPa		_	
12								E, G	10 6 lb/in 2	GPa 3			
13	-	***************************************		**********				ρ	lb/in ³	kg/m ³		_	
15	Х	Part 1:	Weight Properties									-	
16													
17		Fiber Proper							************				
18	-	Variable	Description Material Name:	Value IM7	Units		***************************************						
20		F ₀	Young's Modulus (Longitudinal)	40.03	Msi							-	
21			Young's Modulus (Transverse)	2.76	Msi								
22	1		Shear Modulus (L-T plane)	3.92	Msi							1	
23		G _{fTT}	Shear Modulus (T-T plane)	1.02	Msi								
24			Poisson ratio (L-T plane)	0.2								\perp	
25	-		Poisson ratio (T-T plane)	0.2	Ib/in ³							-	
26	-		Weight Density Tension strength	0.0643 751.3	lb/in ³ Ksi							-	
28			Compression strength	-464.1	Ksi							+	
29			,										
30		Resin Prope		_									
31		Variable	Description Material Name:	Value 3501-6	Units								
32	-	F	Material Name: Young's Modulus	0.631	Msi							+-	
34			Shear Modulus	0.232	Msi								
35			Poisson ratio	0.36									
36		ρ_{m}	Weight Density	0.0469	lb/in ³								
37			Tension strength	8.08	Ksi								
38			Compression strength	-17.18 12.61	Ksi			***************************************				_	
40	-	⊢ ms	Shear Strength	12.01	Ksi							-	
41	Х	Part 2:	MicroMechanics			1 1		1					
42													
43	-	Variable	Description	Value	Units							_	
44 45	-	iAFW AFW	Areal Fiber Weight Units: Areal Fiber Weight:	2 150	$1 = oz/yd^2$, $2 = g/m^2$ oz/yd ² or g/m ²								
46	·	RC	Resin Content (by weight)	30	%								
47													
48													
49 50	Х	Part 3:	Lamina Behavior									-	
51	-	Variable	Description	Value	Units	İ	*****************************					-	
52	1	θ_z	Orientation Angle	20	degrees							1	
53													
54 55	Х	Dort A.	Laminate Behavior*									_	
56	<u> </u>		ninate is a 12-ply maximum where	the lay-up MI	IST be symmetric								
57				, sp									
58		Variable	Description	Value	Units			Definition					
59	-	n	Number of plies (12 max)	8	to als		(#)	$\theta_{\rm i}$ (degree)				4	
60 61	-	t ply	ply thickness Inplane x-direction load	0.03 12000	inch lb/inch		12 11					+-	
62	1	N _x	Inplane y-direction load	0	lb/inch		10					+	
63	-	N _{xv}	Inplane shear load	-1000	lb/inch		9					+	
64		SF	Safety Factor:	1.5			8	0					
65							7	0				1	
66 67							6 5	45 -45				+	
68	-			***************************************			4	-45 -45				-	
69							3	45					
70	-						2	0				4	
71 72	-			***************************************			1		tool surface	***************************************			
73	-											+	
74													
75 <mark>C</mark>		END OF FI	LE										

	АВ	С	D	E	F	G	Н	I	J	K	L	ΜN
1												
2	MA	TLAB P	roject (#3) - Analysis of Composit	te Laminates								П
3			ace Structural Analysis, University of Californ		right J.B. Kosmatka,	2020)						
-												Ŧ
5		version:	Winter, 2020 (v2) - Input: US, Output: US/SI									+
7	Stude	ent Name:	John Kosmatka									+
8			A0123456789									+
9												
10	Pro	oject Title:	03-06-2020 Test Case - 8 ply carbon/epoxy lamin	nate offering high exte	ension and torsion stif	fness/strength. Comm	non in aircraft	wing skins.				T
11												
12	INPUT	ECHO:				ı		i		i		4
13 14		Variable	Description	Value	Haita				Heite D	eference		
15		Variable ilnput	Description Input Units	Value 1	Units 1 = US				US	SI		+
16				1				F	10 ³ lb/in ²	MPa		+
-		iOutput	Output Units	1	1 = US, 2 = SI				10 lb/in 2			+
17								E, G	lb/in ³	GPa kg/m ³		+
18 19		Fiber Prope Variable	Description	Value	Units			ρ	to/th	Kg/m		-
20		Variable	Material Name:	IM7	Offics							+
21		Eft	Young's Modulus (Longitudinal)	40.03	Msi							+
22	+		Young's Modulus (Transverse)	2.76	Msi							H
23	+		Shear Modulus (L-T plane)	3.92	MSi							H
24			Shear Modulus (T-T plane)	1.02	Msi							Ħ
25			Poisson ratio (L-T plane)	0.2								П
26		V _{fTT}	Poisson ratio (T-T plane)	0.2								П
27			Weight Density	0.0643	Ksi							П
28	[Tension strength	751.3	Ksi							Ц
29		F _{FC}	Compression strength	-464.1	Ksi							Н
30	+	Resin Prop	artias									H
32	 	Variable	Description	Value	Units							H
33	1 1		Material Name:	3501-6								T
34		Em	Young's Modulus	0.631	Msi							T
35		G _m	Shear Modulus	0.232	Msi							
36			Poisson ratio	0.36								Ш
37			Weight Density	0.0469	lb/in^3							
38			Tension strength	8.08	Ksi							+-
39 40			Compression strength Shear Strength	-17.18 12.61	Ksi Ksi							+
41	-	· ms	Silear Strength	12.01	K3I							+-
42		MicroMech	nanics									+
43		Variable	Description	Value	Units							
44		iAFW	Areal Fiber Weight Units:	2								
45 46		AFW RC	Areal Fiber Weight:	150 30	g/m^2		Laurinata	Definition				₩.
47		KL	Resin Content (by weight)	30			(#)	Definition θ_i (degree)				+
48		Lamina Bel	havior				12	O ((degree)				+
49		Variable	Description	Value	Units		11					+
50		θ_z	Orientation Angle	20	degrees		10					T
51							9					
52		Laminate B					8	0				Ц.
53 54		Variable	Description	Value	Units		7 6	0 45				-
55	+	n t ply	Number of plies (12 max) ply thickness	8 0.03	inch		5	-45 -45				H
56			Inplane x-direction load	12000	lb/in		4	-45				H
57		N _v	Inplane y-direction load	0	lb/in		3	45				T
58		N _{xy}	Inplane shear load	-1000	lb/in		2	0				Ħ
59		SF	Safety Factor:	1.5			1	0	tool surface			Ħ
60						"				///.		П
61	OLITE	IT.										Ц
62 63	OUTPU	JI:										H
64	Х	Part 1:	Weight Properties		1	I .		l 				ч
65												П
66												П
67	<u> </u>	Variable	Description	Value	Units							H
68 69	 		Volume Fraction (Fiber) Volume Fraction (Resin)	0.62989 0.37011								H
70	+		Weight Fraction (Fiber)	0.37011								H
71			Weight Fraction (Resin)	0.30000								T
72		ρ_c	Composite density	0.05786								П
73		t _{ply}	Cured ply thickness	0.00527	inch							Ц
74		P 2	Missalfacturing									Ц
75 76	Х	Part 2:	MicroMechanics			I						H
76		Variable	Description	Value	Units							H
78	+		Young's Modulus (Longitudinal)	25.4481	Msi							H
79			Young's Modulus (Transverse)	1.2274	Msi							Ħ
80		G _{LT}	Shear Modulus (L-T plane)	0.5695	Msi							I
81			Shear Modulus (T-T plane)	0.4873	Msi			_		_		П
82			Poisson ratio (L-T plane)	0.2592								1
83			Poisson ratio (T-T plane)	0.2592	Vei							H
84 85	+		Tension Strength (Longitudinal) Tension Strength (Transverse)	477.6214 7.0593								+
03	1	* 2t	rension sulengui (Transverse)	7.0393	No.	l .		1				1

					_	_				.,	
A A	В	С	D Comment (I a mail of the D)	E 457 6250	F	G	Н		J	K	L N
86		F _{1c}	Compression Strength (Longitudinal)	-157.6250	Ksi						
87			Compression Strength (Fiber Failure)	-292.3331	Ksi						
88			Compression Strength (Micro-Buckling)	-569.4834	Ksi						
89			Compression Strength (Delamination)	-157.6250	Ksi						
90		F _{2c}	Compression Strength (Transverse)	-15.0097	Ksi						
91		F _{s6}	Shear Strength (1-2 plane)	10.6671	Ksi						
92											
93	Х	Part 3:	Lamina Behavior								
94											
95		2-D materia	I reduced stiffness [Q]:	2.55309E+01	3.19185E-01	0.00000E+00					
96				3.19185E-01	1.23134E+00	0.0000E+00	Msi	units			
97				0.00000E+00	0.00000E+00	5.69483E-01	14131	units			
98				0.00000L+00	0.00000L+00	J.09483L-01					
99		2-D materia	I reduced compliance [S]:	3.92956E-02	-1.01861E-02	0.0000E+00					
100				-1.01861E-02	8.14763E-01	0.00000E+00	1/Msi	units			
101				0.00000E+00	0.00000E+00	1.75598E+00					
102											
103		Orientation	Angle (θz):	20	degrees						
104					_						
105		Transforma	tion matrix [T ₁ ']	8.83022E-01	1.16978E-01	6.42788E-01					
106		Transforme	tion matrix [11]			-6.42788E-01					
				1.16978E-01	8.83022E-01						
107				-3.21394E-01	3.21394E-01	7.66044E-01					
108											
109		Transforma	tion matrix [T2']	8.83022E-01	1.16978E-01	-6.42788E-01		<u></u>	<u> </u>		
110				1.16978E-01	8.83022E-01	6.42788E-01					
111				3.21394E-01	-3.21394E-01	7.66044E-01					
112											
113		2-D materi	Il reduced stiffness [Q-bar]:	2.02252E+01	2.78232E+00	6.84031E+00					+
	\vdash	□ materia	in reduced strinless [Q-Dal].				Mei	units			
114	\vdash			2.78232E+00	1.61071E+00		Msi	units			
115				6.84031E+00	9.69405E-01	3.03262E+00					
116											
117	<u> </u>	2-D materia	I reduced compliance [S-bar]:	2.21067E-01	-1.01245E-01	-4.66269E-01				<u> </u>	LT
118				-1.01245E-01	8.15109E-01		1/Msi	units			
119				-4.66269E-01	-3.21919E-02	1.39174E+00					
120											
121	\vdash										
122		Variable	Description	Value	Units						+
	+-			_							
123		E _x	Young's Modulus (x -direction)	4.5235	Msi						
124		E _y	Young's Modulus (y-direction)	1.2268	Msi						
125		G xy	Shear Modulus (x-y plane)	0.7185	Msi			·		· ·	
126		ν_{xy}	Poisson Ratio (x-y plane)	0.4580							
127			Extension-Shear coupling (x-direction, x-y plane								
_	+	$\eta_{x,xy}$									+
128		$\eta_{y,xy}$	Extension-Shear coupling (y-direction, x-y plan	-0.0395							
129											
130		F* _{1T}	Allowable Fiber Direction Tension Strength	318.4143	Ksi						
131		F* 1C	Allowable Fiber Direction Compression Strengt	h -105.0833	Ksi			·		<u> </u>	
132		F* _{2T}	Allowable Matrix Direction Tension Strength	4.7062	Ksi						
133		F* 2C	Allowable Matrix Direction Compression Streng		Ksi						
134		F* s	Allowable Shear Strength	7.1114	Ksi						
		1 5	Allowable Shear Strength	7.1114	V2I						
135											
136											L
137	Х	Part 4:	Laminate Behavior								_
138											
139		In-Plane St	iffness Relationship	([A])()				
140			N_{x}	3.95406E+06	7.91982E+05	0.00000E+00	€ _{xxo}	units			
141			N _v =		1.03812E+06	0.00000E+00		lb/in	1		
142				0.00000E+00	0.0000E+00	8.52053E+05	- //-		1		
143			N _{xy}	0.000002+00	J.00000E+00		γ _{xyo}				<u> </u>
				1			- '				
144			N 0:1# F 1 :: 11								
145	\vdash	inverse In-	Plane Stiffness Relationship								
146	\vdash		()	4	[A*]		1	<u></u>		1	
147			ε_{xxo}	2.98520E-07	-2.27742E-07	0.0000E+00	N_{x}		3.58224E-03		
148	L I		ε _{yyo} =	-2.27742E-07	1.13703E-06	0.00000E+00	N_{y}	.=.	-2.73290E-03	inch/inch	∟ ⊤
149			γχγο	0.00000E+00	0.00000E+00	1.17364E-06	N_{xy}		-1.17364E-03		
150			(")	<u> </u>)(ļ (,	
151											
152		Equivalent	Laminate Stiffness Properties (In-Plane And	alvsis)							
153	1			Value	Units						+
_		Variable	Description		Oilles						
154		Variable	Description	_	Contract of the Contract of th						
155		t lam	Laminate Thickness	0.24	inch						
150			•	_	inch Msi						
156		t lam	Laminate Thickness	0.24							
_		t _{lam} E _x E _y	Laminate Thickness Young's Modulus (x-direction) Young's Modulus (y-direction)	0.24 13.9577 3.6645	Msi Msi						
157		E _x E _y G _{xy}	Laminate Thickness Young's Modulus (x-direction) Young's Modulus (y-direction) Shear Modulus (x-y plane)	0.24 13.9577 3.6645 3.5502	Msi						
_		t _{lam} E _x E _y	Laminate Thickness Young's Modulus (x-direction) Young's Modulus (y-direction)	0.24 13.9577 3.6645	Msi Msi						
157		t_{lam} E_x E_y G_{xy} V_{xy}	Laminate Thickness Young's Modulus (x-direction) Young's Modulus (y-direction) Shear Modulus (x-y plane)	0.24 13.9577 3.6645 3.5502	Msi Msi						
157 158 159		t_{lam} E_x E_y G_{xy} V_{xy} $\eta_{x,xy}$	Laminate Thickness Young's Modulus (x-direction) Young's Modulus (y-direction) Shear Modulus (x-y plane) Poisson Ratio (applied x, measured y) Extension-Shear Coupling (x, xy)	0.24 13.9577 3.6645 3.5502 0.7629	Msi Msi						
157 158 159 160		$ \begin{array}{c} t_{lam} \\ E_x \\ E_y \\ G_{xy} \\ V_{xy} \\ \eta_{x,xy} \\ \eta_{y,xy} \end{array} $	Laminate Thickness Young's Modulus (x-direction) Young's Modulus (y-direction) Shear Modulus (x-y plane) Poisson Ratio (applied x, measured y) Extension-Shear Coupling (x, xy) Extension-Shear Coupling (y, xy)	0.24 13.9577 3.6645 3.5502 0.7629 0.0000	Msi Msi						
157 158 159 160 161		t_{lam} E_x E_y G_{xy} V_{xy} $\eta_{x,xy}$	Laminate Thickness Young's Modulus (x-direction) Young's Modulus (y-direction) Shear Modulus (x-y plane) Poisson Ratio (applied x, measured y) Extension-Shear Coupling (x, xy)	0.24 13.9577 3.6645 3.5502 0.7629	Msi Msi						
157 158 159 160 161 162		$ \begin{array}{c} t_{lam} \\ E_x \\ E_y \\ G_{xy} \\ V_{xy} \\ \eta_{x,xy} \\ \eta_{y,xy} \end{array} $	Laminate Thickness Young's Modulus (x-direction) Young's Modulus (y-direction) Shear Modulus (x-y plane) Poisson Ratio (applied x, measured y) Extension-Shear Coupling (x, xy) Extension-Shear Coupling (y, xy)	0.24 13.9577 3.6645 3.5502 0.7629 0.0000	Msi Msi						
157 158 159 160 161 162 163		$ \begin{array}{c} t_{lam} \\ E_x \\ E_y \\ G_{xy} \\ V_{xy} \\ \eta_{x,xy} \\ \eta_{y,xy} \end{array} $	Laminate Thickness Young's Modulus (x-direction) Young's Modulus (y-direction) Shear Modulus (x-y plane) Poisson Ratio (applied x, measured y) Extension-Shear Coupling (x, xy) Extension-Shear Coupling (y, xy)	0.24 13.9577 3.6645 3.5502 0.7629 0.0000	Msi Msi						
157 158 159 160 161 162		$ \begin{array}{c} t_{lam} \\ E_x \\ E_y \\ G_{xy} \\ V_{xy} \\ \eta_{x,xy} \\ \eta_{y,xy} \end{array} $	Laminate Thickness Young's Modulus (x-direction) Young's Modulus (y-direction) Shear Modulus (x-y plane) Poisson Ratio (applied x, measured y) Extension-Shear Coupling (x, xy) Extension-Shear Coupling (y, xy)	0.24 13.9577 3.6645 3.5502 0.7629 0.0000	Msi Msi	Global Stresses (x	sy frame)	Ksi	Local Stresse	s (1,2 frame)	Ksi
157 158 159 160 161 162 163		t_{lam} E_x E_y G_{xy} V_{xy} $\eta_{x,xy}$ $\eta_{y,xy}$ Iso-Check	Laminate Thickness Young's Modulus (x-direction) Young's Modulus (y-direction) Shear Modulus (x-y plane) Poisson Ratio (applied x, measured y) Extension-Shear Coupling (x, xy) Extension-Shear Coupling (y, xy) In-plane Isotropic Check (1.00)	0.24 13.9577 3.6645 3.5502 0.7629 0.0000 0.0000 0.703910829	Msi Msi Msi inch	Global Stresses (x σ _{cc}			Local Stresse		
157 158 159 160 161 162 163 164 165		t_{lam} E_x E_y G_{xy} V_{xy} $\eta_{x,xy}$ $\eta_{y,xy}$ $Iso-Check$ $Ply stresses$ $Ply (\#)$	Laminate Thickness Young's Modulus (x-direction) Young's Modulus (y-direction) Shear Modulus (x-y plane) Poisson Ratio (applied x, measured y) Extension-Shear Coupling (x, xy) Extension-Shear Coupling (y, xy)	0.24 13.9577 3.6645 3.5502 0.7629 0.0000 0.703910829 Ply Depth	Msi Msi Msi		s,y frame)	Ksi t _{xy}		s (1,2 frame) • • • • • • • • • • • • • • • • • • •	Ksi T ₁₂
157 158 159 160 161 162 163 164 165 166		$\begin{array}{c} I_{lam} \\ E_x \\ E_y \\ G_{xy} \\ V_{xy} \\ \eta_{x,xy} \\ \eta_{y,xy} \\ Iso-Check \\ \\ \hline \textit{Ply stresses} \\ \textit{Ply (#)} \\ 12 \\ \end{array}$	Laminate Thickness Young's Modulus (x-direction) Young's Modulus (y-direction) Shear Modulus (x-y plane) Poisson Ratio (applied x, measured y) Extension-Shear Coupling (x, xy) Extension-Shear Coupling (y, xy) In-plane Isotropic Check (1.00)	0.24 13.9577 3.6645 3.5502 0.7629 0.0000 0.703910829 Ply Depth	Msi Msi Msi inch						
157 158 159 160 161 162 163 164 165 166 167		$\begin{array}{c} I_{lam} \\ E_x \\ E_y \\ G_{xy} \\ V_{xy} \\ \eta_{x,xy} \\ \eta_{y,xy} \\ Iso-Check \\ \\ \hline \textit{Ply stresses} \\ \textbf{Ply (#)} \\ 12 \\ 11 \\ \end{array}$	Laminate Thickness Young's Modulus (x-direction) Young's Modulus (y-direction) Shear Modulus (x-y plane) Poisson Ratio (applied x, measured y) Extension-Shear Coupling (x, xy) Extension-Shear Coupling (y, xy) In-plane Isotropic Check (1.00)	0.24 13.9577 3.6645 3.5502 0.7629 0.0000 0.703910829 Ply Depth	Msi Msi Msi inch						
157 158 159 160 161 162 163 164 165 166 167 168		$\begin{array}{c} I_{lam} \\ E_x \\ E_y \\ G_{xy} \\ V_{XY} \\ \eta_{XXY} \\ \eta_{YXY} \\ Iso-Check \\ \hline \textit{Ply stresses} \\ \textit{Ply (#)} \\ 12 \\ 11 \\ 10 \\ \end{array}$	Laminate Thickness Young's Modulus (x-direction) Young's Modulus (y-direction) Shear Modulus (x-y plane) Poisson Ratio (applied x, measured y) Extension-Shear Coupling (x, xy) Extension-Shear Coupling (y, xy) In-plane Isotropic Check (1.00)	0.24 13.9577 3.6645 3.5502 0.7629 0.0000 0.703910829 Ply Depth	Msi Msi Msi inch						
157 158 159 160 161 162 163 164 165 166 167 168		E_{x} E_{y} G_{xy} V_{xy} $\eta_{x,xy}$ $\eta_{y,xy}$ $Iso-Check$ $Ply stresses$ $Ply (#)$ 12 11 10 9	Laminate Thickness Young's Modulus (x-direction) Young's Modulus (x-y plane) Poisson Ratio (applied x, measured y) Extension-Shear Coupling (x, xy) In-plane Isotropic Check (1.00) Ply Angle (degree)	0.24 13.9577 3.6645 3.5502 0.7629 0.0000 0.0000 0.703910829 Ply Depth Bottom	Msi Msi Msi inch Top	σ _{xx}	буу	τ _{xy}	σ ₁₁	G ₂₂	T ₁₂
157 158 159 160 161 162 163 164 165 166 167 168		$\begin{array}{c} I_{lam} \\ E_x \\ E_y \\ G_{xy} \\ V_{XY} \\ \eta_{XXY} \\ \eta_{YXY} \\ Iso-Check \\ \hline \textit{Ply stresses} \\ \textit{Ply (#)} \\ 12 \\ 11 \\ 10 \\ \end{array}$	Laminate Thickness Young's Modulus (x-direction) Young's Modulus (y-direction) Shear Modulus (x-y plane) Poisson Ratio (applied x, measured y) Extension-Shear Coupling (x, xy) Extension-Shear Coupling (y, xy) In-plane Isotropic Check (1.00)	0.24 13.9577 3.6645 3.5502 0.7629 0.0000 0.703910829 Ply Depth	Msi Msi Msi inch						

A	В	С	D	E	F	G	Н	1	J	K	L	ΜN
172		6	45	0.03	0.06	2.285	-4.908	-2.505	-3.817	1.194	-3.596	
173		5	-45	0	0.03	16.544	9.351	-12.825	25.772	0.123	3.596	
174		4	-45	-0.03	0	16.544	9.351	-12.825	25.772	0.123	3.596	
175		3	45	-0.06	-0.03	2.285	-4.908	-2.505	-3.817	1.194	-3.596	
176		2	0	-0.09	-0.06	90.586	-2.222	-0.668	90.586	-2.222	-0.668	
177		1	0	-0.12	-0.09	90.586	-2.222	-0.668	90.586	-2.222	-0.668	
178	2		tool surface									
179												П
180												П
181	End o	f Output										