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TI-59 MAGNETIC CARD CALCULATOR SOLUTIONS TO COMPOSITE MATERIALS FORMULAS

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Nonmetallic Materials Division

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Final Report for Period January 1980 to December 1980

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AIR FORCE WRIGHT AERONAUTICAL LABORATORIES
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WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433

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S. W. TSAI, Project Engineer & Chief
Mechanics & Surface Interactions Br.
Nonmetallic Materials Division

FOR THE COMMANDER

F. D. CHERRY, Chief
Nonmetallic Materials Division

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In-Plane and Flexural Stiffness & Strength
Nonmechanical Resultants & Moments
Asymmetric Laminates

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This volume contains the description and instructions of magnetic cards for TI-59 programmable calculators. These tapes contain the key calculations of the stiffness and strength of unidirectional and laminated composites. Both in-plane and flexural loadings can be applied. The initial stress and strain due to curing and moisture adsorption are also included in the strength calculation. With the aid of the magnetic cards, instant calculations can be made for practical use. The use of cards is also an effective teaching tool.

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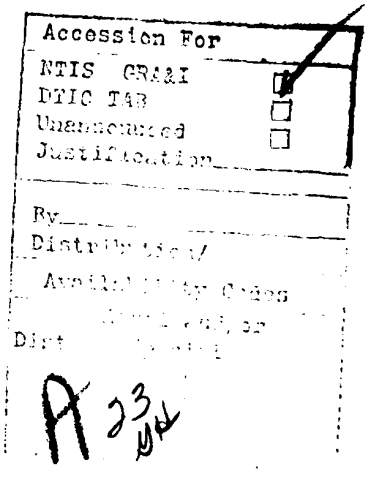
The formulas used in the cards and equation numbers have been derived in a book entitled, Introduction to Composite Materials, coauthored by S. W. Tsai and H. T. Hahn, published by Technomic Publishing Company, Westport, CT, July 1980. This TR a revised edition of the technical report bearing the same number published in April 1979.

FOREWORD

This report was prepared in the Mechanics and Surface Interactions Branch (AFWAL/MLBM), Nonmetallic Materials Division, Materials Laboratory, Air Force Wright Aeronautical Laboratories, Wright-Patterson AFB, Ohio. The work was performed under the support Project No. 2419, "Nonmetallic Structural Materials", Task No. 241903, "Composite Materials and Mechanics Technology". The time period covered by this effort was from January to December 1980. Stephen W. Tsai (AFWAL/MLBM) was the laboratory project engineer. Rodolfo Aoki was a visiting scientist with MLBM from the German Aerospace Research Establishment (DFVLR).

This is a revised edition of the technical report bearing the same number published in April 1979. The asymmetric laminate tapes are added in this revision. The equations and table numbers which appear in the flow charts are the same as in Introduction to Composite Materials, coauthored by S. W. Tsai and H. T. Hahn, published by Technomic Publishing Company, Westport, CT, in July 1980.



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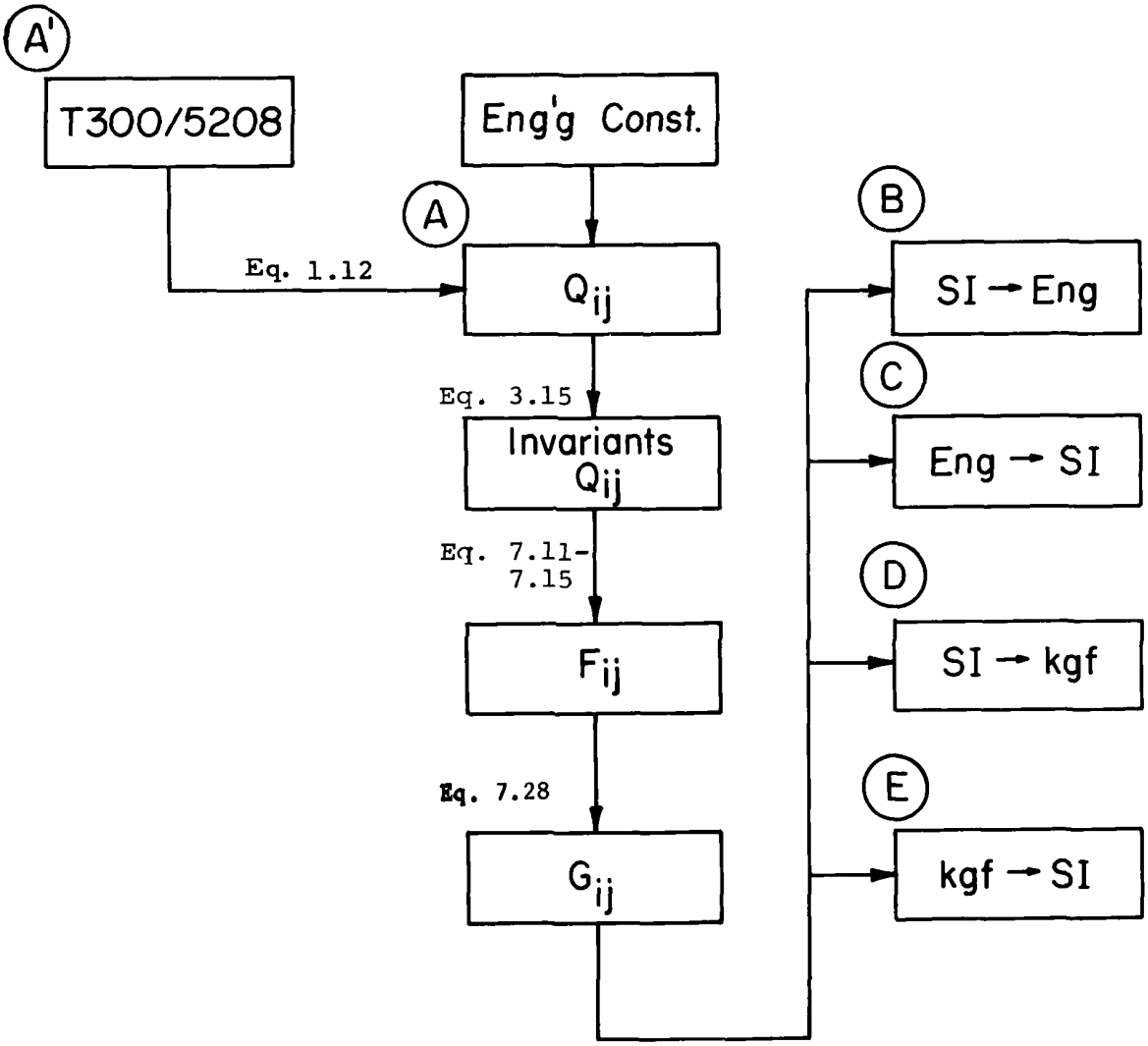
TAPE #1
PROPERTIES OF UNIDIRECTIONAL COMPOSITES



USER INSTRUCTIONS

TAPE #1: PROPERTIES OF UNIDIRECTIONAL COMPOSITES

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	For T300/5208 plies, initialize values of $E_x, E_y, \nu_x, E_s, X, X', Y, Y', S, F^*_{xy}$	--	A'	1.00
	($= -1/2$), ν_y, $\eta_{x,x}$, $\eta_{y,y}$, and h_o in SI.			
	Calculate Q_{ij} invariants $\frac{1}{2}(U_1 + U_4)$, U_5			1.00
	U_2, and U_3; stress failure tensors F_i and F_{ij}; strain failure tensors G_i and G_{ij}.			
2	Convert from SI to English (lb, in, °F) units.	--	B	1.00
3	Convert from English to SI units.	--	C	1.00
4	Convert from SI to kgf (kgf, mm, °C) units.	--	D	1.00
5	Convert from kgf to SI units	--	E	1.00
Alternatives				
0A	Clear memory		CMs	
1A	To initialize other values of E_x,	E_x	STO 18	E_x
	..., h_o, the values may be stored	.	.	.
	manually in the data registers.	.	.	.
2A	Calculate Q_{ij}, U's, F_i, F_{ij}, etc.	--	A	1.00

Then Steps 2-5 can be performed as appropriate. For example, one can initialize in Eng. units and convert to SI by using Step 3.

Computed ply data should be recorded in blocks 3 and 4 for future use. Tape #1 need not be run, unless a change in unit (e.g. from SI to Eng) or change in properties is desired.

Tape #1 Title PROPERTIES OF UNIDIRECTIONAL COMPOSITES

A' Initialize T300/5208	B'	C'	D'	E'
A Initialize Other Mat'l	B SI to English	C English to SI	D SI to kgf/mm^2	E kgf/mm^2 to SI
00	15 Y	30 Q_{ss}	45 U_3	
01 Q_{xx}	16 Y'	31	46 F_{xx}	
02 Q_{yy}	17 S	32	47 F_x	
03 Q_{xy}	18 E_x	33	48 F_{yy}	
04	19 E_y	34	49 F_y	
05	20 ν_x	35	50 F^*_{xy}	
06	21 E_s	36	51 F_{xy}	
07	22 α_x	37	52	
08	23 α_y	38	53	
09	24 β_x	39 m	54 G_{xx}	
10	25 β_y	40	55 G_{yy}	
11	26	41 h_o	56 G_{xy}	
12	27 Q_{xx}	42 $\frac{1}{2}(U_1+U_4)$	57 G_{ss}	
13 X	28 Q_{yy}	43 $U_5=\frac{1}{2}(U_1-U_4)$	58 G_x	
14 X'	29 Q_{xy}	44 U_2	59 G_y	

Tape #1 Properties of Unidirectional

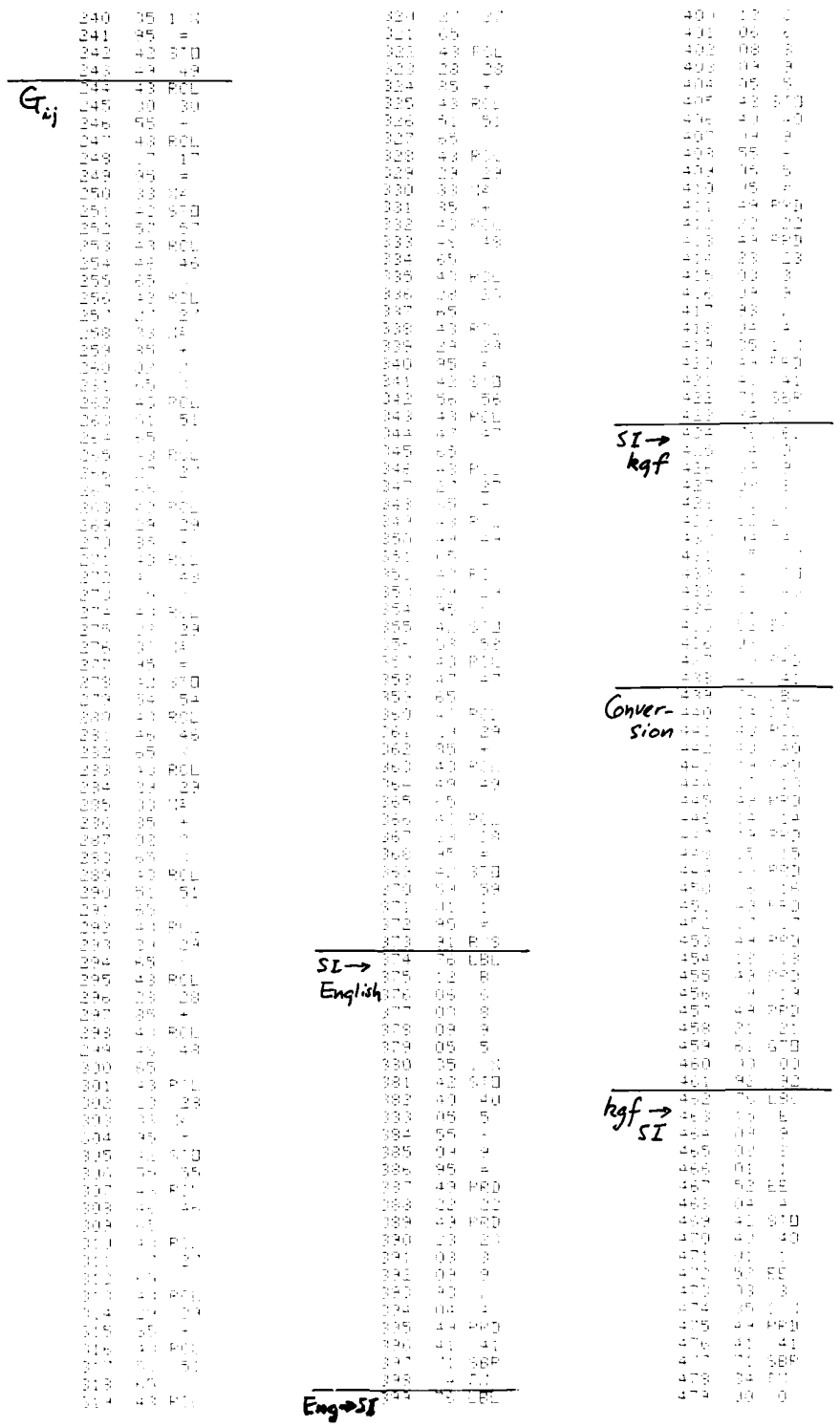
T300-5208

New Mat'l

Q_{ij}

F_{ij}

000	76	LBL		080	24	24		160	43	43					
001	16	H'		081	93	.		161	75	-					
002	01	1		082	06	6		162	43	RCL					
003	07	7		083	42	STO		163	30	30					
004	16	PRD		084	25	25		164	95	=					
005	47	CMS		085	01	1		165	42	STO					
006	37	ENG		086	02	2		166	45	45					
007	01	1		087	05	5		167	43	RCL					
008	16	6		088	52	EE		168	24	24					
009	01	1		089	34	√x		169	85	+					
010	52	EE		090	06	6		170	43	RCL					
011	09	9		091	42	STO		171	28	28					
012	42	STO		092	41	41		172	85	+					
013	18	18		093	74	CSL		173	02	2					
014	01	1		094	11	A		174	65	×					
015	00	0		095	37	ENG		175	43	RCL					
016	08	8		096	43	RCL		176	29	29					
017	52	EE		097	20	20		177	95	=					
018	08	8		098	85	+		178	55	÷					
019	42	STO		099	65	×		179	04	4					
020	19	19		100	43	RCL		180	95	=					
021	43	RCL		101	19	19		181	42	STO					
022	02	2		102	55	÷		182	42	42					
023	06	6		103	43	RCL		183	43	RCL					
024	42	STO		104	18	18		184	07	07					
025	20	20		105	75	-		185	75	-					
026	17	17		106	01	1		186	43	RCL					
027	02	2		107	85	+		187	28	28					
028	07	7		108	44	(		188	95	=					
029	52	EE		109	35	1/x		189	50	IND					
030	09	9		110	42	STO		190	55	÷					
031	42	STO		111	39	39		191	02	2					
032	21	21		112	55	÷		192	95	=					
033	01	1		113	43	RCL		193	42	STO					
034	05	5		114	18	18		194	44	44					
035	52	EE		115	95	=		195	43	RCL					
036	08	8		116	42	STO		196	13	13					
037	42	STO		117	22	22		197	65	×					
038	13	13		118	42	STO		198	43	RCL					
039	42	STO		119	01	01		199	14	14					
040	14	14		120	43	RCL		200	95	=					
041	04	4		121	39	39		201	85	+					
042	52	EE		122	65	×		202	42	STO					
043	07	7		123	43	RCL		203	46	46					
044	42	STO		124	19	19		204	43	RCL					
045	15	15		125	95	=		205	13	13					
046	02	2		126	42	STO		206	25	1/x					
047	06	6		127	28	28		207	75	-					
048	04	4		128	42	STO		208	43	RCL					
049	52	EE		129	02	02		209	14	14					
050	06	6		130	65	×		210	35	1/x					
051	42	STO		131	43	RCL		211	95	=					
052	16	16		132	20	20		212	42	STO					
053	75	-		133	95	=		213	47	47					
054	01	1		134	42	STO		214	43	RCL					
055	52	EE		135	29	29		215	15	15					
056	05	5		136	42	STO		216	55	÷					
057	42	STO		137	03	03		217	43	RCL					
058	11	11		138	43	RCL		218	16	16					
059	43	RCL		139	21	21		219	95	=					
060	03	3		140	42	STO		220	35	1/x					
061	44	(		141	30	30		221	42	STO					
062	01	1		142	65	×		222	48	48					
063	85	+		143	04	4		223	65	×					
064	01	1		144	75	-		224	43	RCL					
065	00	0		145	02	2		225	46	46					
066	45	)		146	55	÷		226	95	=					
067	45	)		147	43	RCL		227	34	√x					
068	42	STO		148	29	29		228	65	×					
069	12	12		149	85	+		229	43	RCL					
070	01	1		150	43	RCL		230	50	50					
071	00	0		151	24	24		231	95	=					
072	06	6		152	85	+		232	42	STO					
073	52	EE		153	43	RCL		233	51	51					
074	43	(		154	28	28		234	43	RCL					
075	01	1		155	95	=		235	15	15					
076	42	STO		156	55	÷		236	25	1/x					
077	13	13		157	08	8		237	75	-					
078	43	RCL		158	95	=		238	43	RCL					
079	42	STO		159	42	STO		239	16	16					

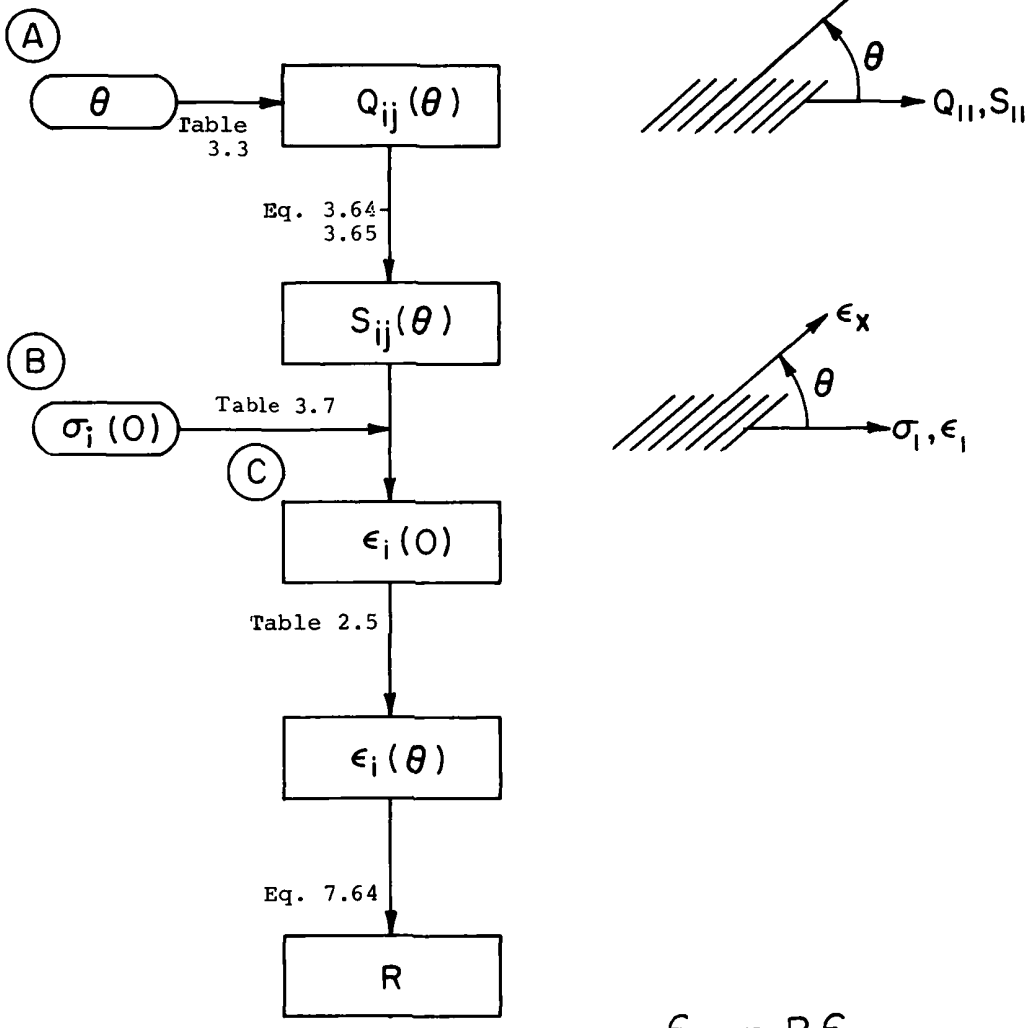

G_{ij}
SI→ English
Eng→SI
SI→ kgf
Conver- sion
kgf→ SI

T300/5208

AS/3501

	SI	ENG.	Kgf/MM^2	SI	ENG.	
	0. 00	0. 00	0. 00	0. 00	0. 00	00
	181.31114 09	26.3e8543 06	18.533246 03	138.78041 09	20.127688 06	01
	10.346159 09	1.5005306 06	1.0546543 03	9.0162185 09	1.3076459 06	02
	2.8e69244 09	420.14858 03	295.30321 00	2.7048656 09	392.29377 03	03
	0. 00	0. 00	0. 00	0. 00	0. 00	04
	0. 00	0. 00	0. 00	0. 00	0. 00	05
	0. 00	0. 00	0. 00	0. 00	0. 00	06
	0. 00	0. 00	0. 00	0. 00	0. 00	07
	0. 00	0. 00	0. 00	0. 00	0. 00	08
	0. 00	0. 00	0. 00	0. 00	0. 00	09
	0. 00	0. 00	0. 00	0. 00	0. 00	10
	0. 00	0. 00	0. 00	0. 00	0. 00	11
	0. 00	0. 00	0. 00	0. 00	0. 00	12
	1.5 09	217.54895 03	152.9052 00	1.44795 09	210. 03	13
	1.5 09	217.54895 03	152.9052 00	1.44795 09	210. 03	14
	40. 06	5.8013053 03	4.077472 00	51.7125 06	7.5 03	15
	346. 06	35.676027 03	25.076453 00	206.85 06	30. 03	16
	68. 06	9.8622219 03	6.93170223 00	93.0825 06	13.5 03	17
	181. 09	26.250506 06	18.450561 03	137.96895 09	20.01 06	18
	10. 09	1.4933361 06	1.0499949 03	8.9635 09	1.3 06	19
	280. -03	280. -03	280. -03	300. -03	300. -03	20
	1. 09	1.0744e14 06	730.88685 00	7.10185 09	1.03 06	21
	10. -09	5.9555556-09	10. -09	10. 09	5.5555554 09	22
	12.5-06	6.8444444-06	12.5-06	12.5-06	6.9444444-06	23
	0. 00	0. 00	0. 00	0. 00	0. 00	24
	600. -03	600. -03	600. -03	600. -03	600. -03	25
	0. 00	0. 00	0. 00	0. 00	0. 00	26
Q_{ij}	181.31114 09	26.3e8543 06	18.533246 03	138.78041 09	20.127688 06	27
Q_{ij}	10.346159 09	1.5005306 06	1.0546543 03	9.0162185 09	1.3076459 06	28
Q_{ij}	2.8e69244 09	420.14858 03	295.30321 00	2.7048656 09	392.29377 03	29
Q_{ij}	1.5 09	217.54884 03	730.88685 00	7.10185 09	1.03 06	30
	0. 00	0. 00	0. 00	0. 00	0. 00	31
	0. 00	0. 00	0. 00	0. 00	0. 00	32
	0. 00	0. 00	0. 00	0. 00	0. 00	33
	0. 00	0. 00	0. 00	0. 00	0. 00	34
	0. 00	0. 00	0. 00	0. 00	0. 00	35
	0. 00	0. 00	0. 00	0. 00	0. 00	36
	0. 00	0. 00	0. 00	0. 00	0. 00	37
	0. 00	0. 00	0. 00	0. 00	0. 00	38
	1.0044814 00	1.0044814 00	1.0044814 00	1.00588815 00	1.00588815 00	39
	0. 00	145.03263-06	101.9768-09	0. 00	145.03263-06	40
	125. -06	4.925-03	125. -03	133.24846-06	5.2499893-03	41
	49.[illegible] 09	7.177344 06	5.0446366 03	38.30159 09	5.5549804 06	42
	24.[illegible]431 09	3.8985397 06	2.7401051 03	21.144287 09	3.0963433 06	43
	35.[illegible]249 09	12.434009 06	8.7392956 03	54.882045 09	9.4100211 06	44
	19.710491 09	2.8586557 06	2.0092183 03	14.147437 09	2.0663433 06	45
	444.44444-21	21.129344-12	42.7716-06	476.47133-21	22.675737-12	46
	0. 00	0. 00	0. 00	0. 00	0. 00	47
	101.e2e02-18	4.831405-09	9.7800915-03	93.296508-18	4.4444444-09	48
	20.934959-09	144.34654-06	205.37195-03	14.503263-09	100.-06	49
	-500. -03	-500. -03	-500. -03	0. 00	0. 00	50
	-3.3e03242-18	-159.75326-12	-323.38451-06	0. 00	0. 00	51
	0. 00	0. 00	0. 00	0. 00	0. 00	52
	0. 00	0. 00	0. 00	0. 00	0. 00	53
G_{ij}	12.004384 03	12.004384 03	12.004384 03	8.8704565 03	8.8704565 03	54
G_{ij}	10.680652 03	10.680652 03	10.680652 03	7.6033133 03	7.6033133 03	55
G_{ij}	-3.0691033 03	-3.0691033 03	-3.0691033 03	2.4589639 03	2.4589639 03	56
G_{ij}	11.117843 03	11.117842 03	11.117842 03	5.8211248 03	5.8211248 03	57
G_{ij}	60.646995 00	60.646995 00	60.646995 00	39.229377 00	39.229377 00	58
G_{ij}	216.59641 00	216.59641 00	216.59641 00	130.76459 00	130.76459 00	59

TAPE #2
OFF-AXIS PROPERTIES OF UNIDIRECTIONAL COMPOSITES



$$\epsilon_{i(a)} = R\,\epsilon_i$$

$$\sigma_{i(a)} = R\,\sigma_i$$

USER INSTRUCTIONS

TAPE #2: OFF-AXIS PROPERTIES OF UNIDIRECTIONAL COMPOSITES

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
0	Ply data must be in storage			
1	Calculate modulus Q_{ij} and compliance S_{ij} in rotated coordinate system at angle θ (positive counterclockwise) to reference coordinates	θ	A	1.00
2	Input applied stresses in reference coord. system. If unit stresses, such as [1,0,0], are entered, the resulting R values are the allowable strengths.	σ_1 σ_2 σ_6	B R/S R/S	σ_1 σ_2 σ_6
3*	Calculate corresponding strains in reference and material coord. systems and calculate strength ratios R & R'. (defined as the ratios by which the applied loading must be multiplied to reach the failure surface).	-- --	C R/S	R R'
Alternative A				
2A	Input applied strains in reference coord. system	ϵ_1 ϵ_2 ϵ_6	STO 10 STO 11 STO 12	ϵ_1 ϵ_2 ϵ_6
3A	Calculate strains in material coord. system, and calculate strength-strain ratios R and R'.	-- --	D R/S	R R'
Alternative B				
2B	Input strains in material coords. (Step 0 needed, but Step 1 not needed)	ϵ_x ϵ_y ϵ_s	STO 07 STO 08 STO 09	ϵ_x ϵ_y ϵ_s
3B	Calculate strength ratios R & R'.	-- -	E R/S	R R'

* Steps 0, 1 and 2 must be executed at least once before Step 3.
If only the angle in Step 1 is changed while the stress remains the same Step 2 can be skipped. If the stress is changed while the angle remains constant, Step 1 can be omitted.

Tape# 2 Title OFF-AXIS PROPERTIES OF UNIDIRECTIONAL COMPOSITES

A'	B'	C'	D'	E'
A θ	B $[\sigma_1, \sigma_2, \sigma_6]$	C R	D R from $[e_1, e_2, e_6]$	E R from $[e_x, e_y, e_s]$
00 θ	15	30 Q_{66}	45 U_3	
01 σ_1	16	31 Q_{16}	46	
02 σ_2	17	32 Q_{26}	47	
03 σ_6	18	33 S_{11}	48	
04	19	34 S_{22}	49	
05	20	35 S_{12}	50	
06	21	36 S_{66}	51	
07 e_x	22	37 S_{16}	52 ...R	
08 e_y	23	38 S_{26}	53 ...R'	
09 e_s	24	39 2θ	54 G_{xx}	
10 e_1	25	40 4θ	55 G_{yy}	
11 e_2	26 $\lvert Q \rvert$	41 h_o	56 G_{xy}	
12 e_6	27 Q_{11}	42 $\frac{1}{2}(U_1+U_4)$	57 G_{ss}	
13	28 Q_{22}	43 $U_5=\frac{1}{2}(U_1-U_4)$	58 G_x	
14	29 Q_{12}	44 U_2	59 G_y	

Tape #2 Off-Axis Properties

θ

000	76	LBL
001	11	A
002	57	ENG
003	42	STO
004	00	00
005	65	×
006	02	2
007	95	=
008	42	STO
009	39	39
010	65	×
011	02	2
012	95	=
013	42	STO
014	40	40
015	01	1
016	03	3
017	56	FND

Q_{ij}

018	43	RCL
019	42	42
020	85	+
021	43	RCL
022	41	41
023	85	+
024	43	RCL
025	39	39
026	34	COS
027	65	×
028	43	RCL
029	41	41
030	85	+
031	43	RCL
032	40	40
033	34	COS
034	65	×
035	43	RCL
036	45	45
037	95	=
038	42	STO
039	27	27
040	75	-
041	43	RCL
042	39	39
043	33	COS
044	65	×
045	02	2
046	65	×
047	43	RCL
048	44	44
049	95	=
050	42	STO
051	28	28
052	43	RCL
053	42	42
054	75	-
055	43	RCL
056	43	43
057	75	-
058	43	RCL
059	40	40
060	33	COS
061	65	×
062	43	RCL
063	45	45
064	95	=
065	42	STO
066	29	29
067	85	+
068	02	2
069	65	×
070	43	RCL
071	42	42
072	75	-
073	43	RCL
074	42	42
075	95	=
076	42	STO
077	30	30
078	43	RCL
079	39	39
080	38	SIN
081	55	÷
082	02	2
083	65	×
084	43	RCL
085	44	44
086	95	=
087	85	+
088	43	RCL
089	40	40
090	34	COS
091	65	×
092	43	RCL
093	45	45
094	95	=
095	42	STO
096	31	31
097	75	-
098	43	RCL
099	39	39
100	38	SIN
101	65	×
102	43	RCL
103	44	44
104	95	=
105	94	+/-
106	42	STO
107	32	32

$|Q|$

108	43	RCL
109	27	27
110	65	×
111	43	RCL
112	28	28
113	65	×
114	43	RCL
115	30	30
116	85	+
117	43	RCL
118	29	29
119	65	×
120	43	RCL
121	31	31
122	65	×
123	43	RCL
124	32	32
125	65	×
126	02	2
127	75	-
128	43	RCL
129	28	28
130	65	×
131	43	RCL
132	31	31
133	33	X²
134	75	-
135	43	RCL
136	27	27
137	65	×
138	43	RCL
139	32	32
140	33	X²
141	75	-
142	43	RCL
143	30	30
144	65	×
145	43	RCL
146	29	29
147	33	X²
148	95	=
149	42	STO
150	26	26

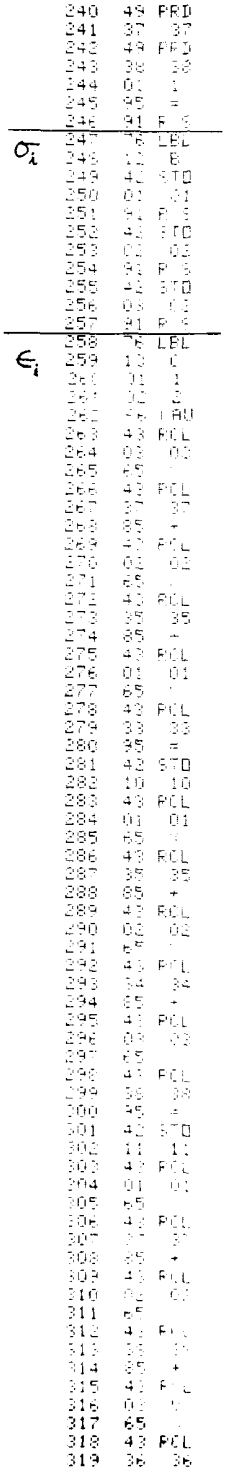
S_{ij}^*

151	43	RCL
152	28	28
153	65	×
154	43	RCL
155	30	30
156	75	-
157	43	RCL
158	32	32
159	33	X²
160	95	=
161	42	STO
162	33	33
163	43	RCL
164	27	27
165	65	×
166	43	RCL
167	28	28
168	75	-
169	43	RCL
170	29	29
171	33	X²
172	95	=
173	42	STO
174	36	36
175	43	RCL
176	27	27
177	65	×
178	43	RCL
179	30	30
180	75	-
181	43	RCL
182	31	31
183	33	X²
184	95	=
185	42	STO
186	34	34
187	43	RCL
188	29	29
189	65	×
190	43	RCL
191	32	32
192	75	-
193	43	RCL
194	28	28
195	65	×
196	43	RCL
197	31	31
198	95	=
199	42	STO
200	37	37
201	43	RCL
202	31	31
203	65	×
204	43	RCL
205	32	32
206	75	-
207	43	RCL
208	29	29
209	65	×
210	43	RCL
211	30	30
212	95	=
213	42	STO
214	35	35
215	43	RCL
216	29	29
217	65	×
218	43	RCL
219	31	31
220	75	-
221	43	RCL
222	27	27
223	65	×
224	43	RCL
225	32	32
226	95	=
227	42	STO
228	38	38

S_{ij}

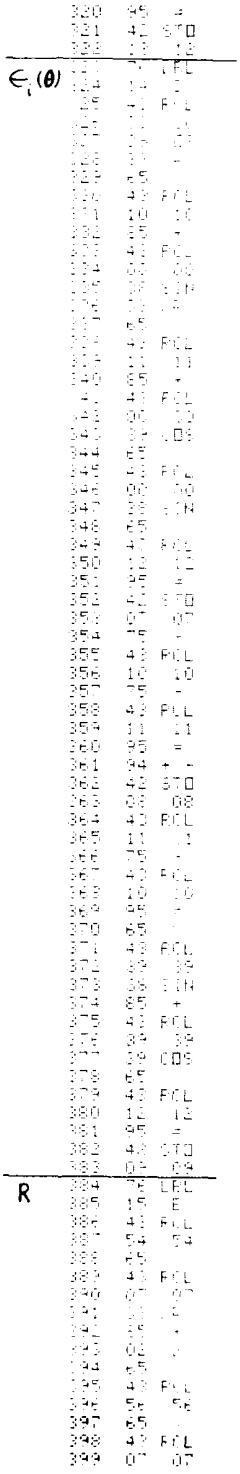
229	43	RCL
230	26	26
231	35	1/X
232	49	PRD
233	33	33
234	49	PRD
235	34	34
236	49	PRD
237	35	35
238	49	PRD
239	36	36

σ_i



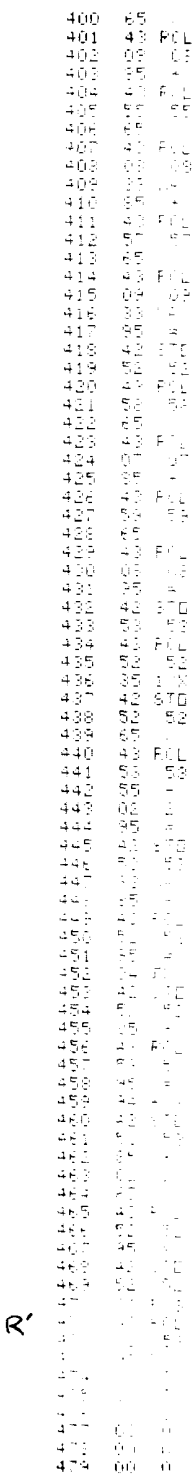
ϵ_i

$\epsilon_i(\theta)$



R

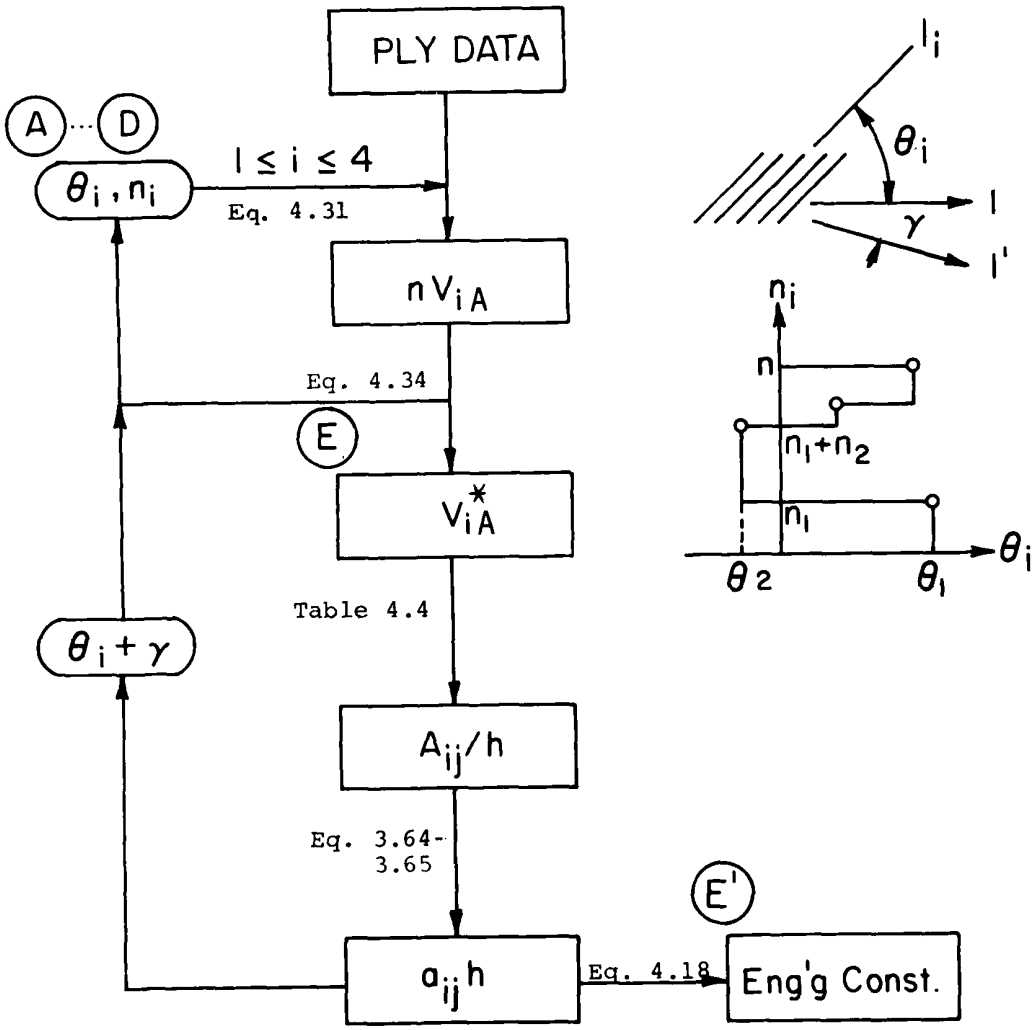
R'



θ	0. 00	15. 00	30. 00	45. 00	
σ_i	1. 00	1. 00	1. 00	1. 00	01
	0. 00	0. 00	0. 00	0. 00	02
	0. 00	0. 00	0. 00	0. 00	03
	0. 00	0. 00	0. 00	0. 00	04
	0. 00	0. 00	0. 00	0. 00	05
	0. 00	0. 00	0. 00	0. 00	06
Q_{ij}	1.5 09	1.5 09	1.5 09	1.5 09	13
	1.5 09	1.5 09	1.5 09	1.5 09	14
	40. 06	40. 06	40. 06	40. 06	15
	246. 06	246. 06	246. 06	246. 06	16
	68. 06	68. 06	68. 06	68. 06	17
	181. 09	181. 09	181. 09	181. 09	18
	10.3 09	10.3 09	10.3 09	10.3 09	19
	280. -03	280. -03	280. -03	280. -03	20
	.1 09	.1 09	.1 09	.1 09	21
	10. -09	10. -09	10. -09	10. -09	22
	12.5 06	12.5 06	12.5 06	12.5 06	23
	0. 00	0. 00	0. 00	0. 00	24
	600. -03	600. -03	600. -03	600. -03	25
	13.486914 30	13.486914 30	13.486914 30	13.486914 30	26
	56.657787 09	56.657787 09	56.657787 09	56.657787 09	27
	42.317787 09	42.317787 09	42.317787 09	42.317787 09	28
	46.590852 09	46.590852 09	46.590852 09	46.590852 09	29
	42.866245 09	42.866245 09	42.866245 09	42.866245 09	30
	59.747083 12	59.747083 12	59.747083 12	59.747083 12	31
	58.747083 12	58.747083 12	58.747083 12	58.747083 12	32
	-9.987924 12	-9.987924 12	-9.987924 12	-9.987924 12	33
	105.70616 12	105.70616 12	105.70616 12	105.70616 12	34
	-45.781256 12	-45.781256 12	-45.781256 12	-45.781256 12	35
	-45.781256 12	-45.781256 12	-45.781256 12	-45.781256 12	36
	90. 00	90. 00	90. 00	90. 00	37
	180. 00	180. 00	180. 00	180. 00	38
	125. -06	125. -06	125. -06	125. -06	39
	49.487787 09	49.487787 09	49.487787 09	49.487787 09	40
	26.880431 09	26.880431 09	26.880431 09	26.880431 09	41
	85.73249 09	85.73249 09	85.73249 09	85.73249 09	42
	19.710431 09	19.710431 09	19.710431 09	19.710431 09	43
	444.44444-21	444.44444-21	444.44444-21	444.44444-21	44
	0. 00	0. 00	0. 00	0. 00	45
	101.62602-18	101.62602-18	101.62602-18	101.62602-18	46
	20.934959-09	20.934959-09	20.934959-09	20.934959-09	47
	-500. -03	-500. -03	-500. -03	-500. -03	48
	-3.3603243-18	-3.3603243-18	-3.3603243-18	-3.3603243-18	49
R	1.5 09	222.22216 06	222.22462 06	64.586589 06	50
	1.5 09	322.82798 06	322.82798 06	322.82798 06	51
	12.004384 03	12.004384 03	12.004384 03	12.004384 03	52
	10.680652 03	10.680652 03	10.680652 03	10.680652 03	53
	-3.0691032 03	-3.0691032 03	-3.0691032 03	-3.0691032 03	54
	11.117842 03	11.117842 03	11.117842 03	11.117842 03	55
	60.646995 00	60.646995 00	60.646995 00	60.646995 00	56
	216.59641 00	216.59641 00	216.59641 00	216.59641 00	57
S_{ij}	5.564-619-12	13.768628-12	3.756306[illegible]-12	[illegible]	58
	47.067379-12	93.064094-12	-83.111624-12	[illegible]	59
	1.5469613-12	-3.657202-12	-160.39[illegible]-12	[illegible]	60
	139.47001-12	131.02905-12	34.746213-12	[illegible]	61
	0. 00	-30.200717-12	-7.8776833-12	[illegible]	62
	0. 00	-15.580541-12	-146.95782[illegible]-12	[illegible]	63
	0. 00	30. 00	-32.337645-12	[illegible]	64
	0. 00	60. 00	60. 00	[illegible]	65
	125. -06	125. -06	120. 00	[illegible]	66
	49.487787 09	49.487787 09	125. -06	[illegible]	67
	26.880431 09	26.880431 09	49.487787 09	[illegible]	68
	85.73249 09	85.73249 09	26.880431 09	[illegible]	69
	19.710431 09	19.710431 09	85.73249 09	[illegible]	70
	444.44444-21	444.44444-21	19.710431 09	[illegible]	71
	0. 00	0. 00	444.44444-21	[illegible]	72
	101.62602-18	101.62602-18	0. 00	[illegible]	73
	20.934959-09	20.934959-09	101.62602-18	[illegible]	74
	-500. -03	-500. -03	20.934959-09	[illegible]	75
	-3.3603243-18	-3.3603243-18	-500. -03	[illegible]	76
	1.5 09	222.22216 06	[illegible]	[illegible]	77
	1.5 09	322.82798 06	[illegible]	[illegible]	78
	12.004384 03	12.004384 03	[illegible]	[illegible]	79
	10.680652 03	10.680652 03	[illegible]	[illegible]	80
	-3.0691032 03	-3.0691032 03	[illegible]	[illegible]	81
	11.117842 03	11.117842 03	[illegible]	[illegible]	82
	60.646995 00	60.646995 00	[illegible]	[illegible]	83
	216.59641 00	216.59641 00	[illegible]	[illegible]	84

TAPE #3

IN-PLANE STIFFNESS OF SYMMETRIC LAMINATES



USER INSTRUCTIONS

TAPE #3: IN-PLANE STIFFNESS OF SYMMETRIC LAMINATES

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
0	Enter ply data.	--		
1	Enter ply angle θ_i, and number of plies at that angle, n_i^*, i=1,4, and	θ_1	A	θ_1
		n_1	R/S	$2n_1$
	calculate $V_{1A}^*, V_{2A}^*, V_{3A}^*$ and V_{4A}^*	θ_2	B	θ_2
	for each ply and sum them, and	n_2	R/S	$2(n_1 + n_2)$
	calculate n . Since $1 \leq i \leq 4$, values	θ_3	C	θ_3
	for nonexisting plies need not be	n_3	R/S	$2(n_1+n_2+n_3)$
	entered, i.e. for a [0/90] laminate,	θ_4	D	θ_4
	i=3 and 4 can be skipped.	n_4	R/S	n
2	Calculate V_{iA}, h, A_{ij}/h, and $a_{ij}h$.	--	E	1.00
3	Calculate engineering constants	--	E'	E_1^o
		--	R/S	E_2^o
		--	R/S	ν_{12}^o
		--	R/S	E_6^o
Alternative A				
1A	Rotate entire laminate by γ; **	γ	A'	$2n_1$
	n_i remain the same	--	B'	$2(n_1 + n_2)$
		--	C'	$2(n_1+n_2+n_3)$
		--	D'	n
2A	Calculate transformed A_{ij}/h and $a_{ij}h$.	--	E	1.00
3A	Calculate engineering constants	--	E'	E_1^o
		--	etc.	

* The number of plies n_i of each ply orientation are those in the upper half of the laminate. The total number for each orientation is $2n_i$. The thickness h in Register 26 is the total thickness of the laminate; the number in Register 46 is one half of the total ply number. For symmetric laminates, only the fraction of each orientation rather than the absolute number of plies is important. If more than four ply orientations are needed, additional θ and n can be entered through Key B, C or D; but not Key A which initializes the program.

** This is equivalent to rotating the reference coordinates in the clockwise or negative direction.

IN-PLANE STIFFNESS OF
SYMMETRIC LAMINATES

Tape# 3 Title

A' $\theta_1+\gamma$, n_1	B' $\theta_2+\gamma$, n_2	C' $\theta_3+\gamma$, n_3	D' $\theta_4+\gamma$, n_4	E' Eng'g Const.
A θ_1, n_1	B θ_2, n_2	C θ_3, n_3	D θ_4, n_4	E A^*_{ij}, a^*_{ij}

00	γ	15	θ_2	30	A_{66}/h	45	U_3
01		16	n_2	31	A_{16}/h	46	$n/2$
02		17	θ_3	32	A_{26}/h	47	V^*_{1A}
03		18	n_3	33	$a_{11}h$	48	V^*_{2A}
04		19	θ_4	34	$a_{22}h$	49	V^*_{3A}
05		20	n_4	35	$a_{12}h$	50	V^*_{4A}
06		21		36	$a_{66}h$	51	
07		22		37	$a_{16}h$	52	
08		23		38	$a_{26}h$	53	
09		24		39	θ_i, $\|A\|$	54	
10		25		40	n_i	55	
11		26	h	41	h_o	56	
12		27	A_{11}/h	42	$\frac{1}{2}(U_1+U_4)$	57	
13	θ_1	28	A_{22}/h	43	$U_5=\frac{1}{2}(U_1-U_4)$	58	
14	n_1	29	A_{12}/h	44	U_2	59	

Tape #3 In-Plane Stiffness

θ_1, n_1

```
000  76 LBL
001  11  A
002  57 ENG
003  42 STO
004  13  .
005  00  0
006  42 STO
007  46  46
008  42 STO
009  47  47
010  42 STO
011  48  48
012  42 STO
013  49  49
014  42 STO
015  50  50
016  43 RCL
017  13  13
018  91 R/S
019  42 STO
020  14  14
021  43 STO
022  40  40
023  44 SUM
024  46  46
025  43 RCL
026  13  13
027  71 SBR
028  33  X²
```

θ_2, n_2

```
029  76 LBL
030  12  B
031  42 STO
032  15  15
033  91 R/S
034  42 STO
035  16  16
036  42 STO
037  40  40
038  44 SUM
039  46  46
040  43 RCL
041  15  15
042  71 SBR
043  33  X²
```

θ_3, n_3

```
044  76 LBL
045  13  C
046  42 STO
047  17  17
048  91 R/S
049  42 STO
050  18  18
051  42 STO
052  40  40
053  44 SUM
054  46  46
055  43 RCL
056  17  17
057  71 SBR
058  33  X²
```

θ_4, n_4

```
059  76 LBL
060  14  D
061  42 STO
062  19  19
063  91 R/S
064  42 STO
065  20  20
066  42 STO
067  40  40
068  44 SUM
069  46  46
070  43 RCL
071  19  19
```

V_{iA}

```
072  76 LBL
073  33  X²
074  65  ×
075  02  2
076  95  =
077  94 +/-
078  42 STO
079  39  39
```

```
080  39 COS
081  65  ×
082  43 RCL
083  40  40
084  95  =
085  44 SUM
086  47  47
087  43 RCL
088  39  39
089  33  X²
090  65  ×
091  43 RCL
092  40  40
093  95  =
094  44 SUM
095  48  48
096  01  1
097  44 SUM
098  39  39
099  43 RCL
100  39  39
101  33  X²
102  65  ×
103  43 RCL
104  40  40
105  95  =
106  44 SUM
107  49  49
108  43 RCL
109  39  39
110  33  X²
111  65  ×
112  43 RCL
113  40  40
114  95  =
115  44 SUM
116  50  50
117  43 RCL
118  46  46
119  65  ×
120  02  2
121  95  =
122  91 R/S
123  76 LBL
124  15  E
125  01  1
126  03  3
127  66 PAU
128  43 RCL
129  46  46
130  35  1/x
131  49 PRD
132  47  47
133  49 PRD
134  48  48
135  49 PRD
136  49  49
137  49 PRD
138  50  50
139  95  =
140  65  ×
141  43 RCL
142  41  41
143  65  ×
144  02  2
145  95  =
146  42 STO
147  26  26
```

A_{ij}/h

```
148  43 RCL
149  42  42
150  85  +
151  43 RCL
152  43  43
153  85  +
154  43 RCL
155  47  47
156  65  ×
157  43 RCL
158  44  44
159  85  +
```

```
160  43 RCL
161  48  48
162  65  ×
163  43 RCL
164  45  45
165  95  =
166  42 STO
167  27  27
168  65  ×
169  03  3
170  55  ÷
171  43 RCL
172  41  41
173  55  ÷
174  43 RCL
175  44  44
176  95  =
177  42 STO
178  28  28
179  43 RCL
180  42  42
181  75  -
182  43 RCL
183  43  43
184  75  -
185  43 RCL
186  48  48
187  55  ÷
188  43 RCL
189  45  45
190  95  =
191  42 STO
192  29  29
193  75  -
194  43 RCL
195  42  42
196  85  +
197  02  2
198  65  ×
199  43 RCL
200  42  42
201  95  =
202  42 STO
203  30  30
204  43 RCL
205  49  49
206  55  ÷
207  43 RCL
208  44  44
209  55  ÷
210  02  2
211  85  +
212  43 RCL
213  50  50
214  55  ÷
215  43 RCL
216  45  45
217  95  =
218  42 STO
219  31  31
220  02  2
221  55  ÷
222  43 RCL
223  47  47
224  55  ÷
225  43 RCL
226  48  48
227  65  ×
228  43 RCL
229  30  30
```

$|A|$

```
240  85  +
241  43 RCL
242  29  29
243  65  ×
244  43 RCL
245  31  31
246  65  ×
247  43 RCL
248  32  32
249  65  ×
250  02  2
251  75  -
252  43 RCL
253  28  28
254  65  ×
255  43 RCL
256  31  31
257  33 X²
258  75  -
259  43 RCL
260  27  27
261  65  ×
262  43 RCL
263  32  32
264  33 X²
265  75  -
266  43 RCL
267  30  30
268  65  ×
269  43 RCL
270  29  29
271  33 X²
272  95  =
273  42 STO
274  39  39
275  43 RCL
276  28  28
277  65  ×
278  43 RCL
279  30  30
280  75  -
281  43 RCL
282  32  32
283  33 X²
284  95  =
285  42 STO
286  33  33
287  43 RCL
288  27  27
289  65  ×
290  43 RCL
291  28  28
292  75  -
293  43 RCL
294  29  29
295  33 X²
296  95  =
297  42 STO
298  36  36
299  43 RCL
300  27  27
301  65  ×
302  43 RCL
303  30  30
304  75  -
305  43 RCL
306  31  31
307  33 X²
308  95  =
309  42 STO
310  34  34
311  43 RCL
312  29  29
313  65  ×
314  43 RCL
315  32  32
316  75  -
317  43 RCL
318  28  28
319  65  ×
```

$a_{ij}^{*}|A|$

```
320  43 RCL
321  31  31
322  95  =
323  42 STO
324  37  37
325  43 RCL
326  31  31
327  65  ×
328  43 RCL
329  32  32
330  75  -
331  43 RCL
332  29  29
333  65  ×
334  43 RCL
335  30  30
336  95  =
337  42 STO
338  35  35
339  43 RCL
340  29  29
341  65  ×
342  43 RCL
343  31  31
344  75  -
345  43 RCL
346  27  27
347  65  ×
348  43 RCL
349  32  32
350  95  =
351  42 STO
352  38  38
353  43 RCL
354  39  39
355  35 1/X
356  49 PRD
357  33  33
358  49 PRD
359  34  34
360  49 PRD
361  35  35
362  49 PRD
363  36  36
364  49 PRD
365  37  37
366  49 PRD
367  38  38
368  01  1
369  95  =
370  91 R/S
371  76 LBL
372  10 E'
373  43 RCL
374  33  33
375  35 1/X
376  91 R/S
377  43 RCL
378  34  34
379  35 1/X
380  91 R/S
381  43 RCL
382  35  35
383  55  ÷
384  43 RCL
385  33  33
386  95  =
387  94 +/-
388  91 R/S
389  43 RCL
390  36  36
391  35 1/X
392  91 R/S
393  76 LBL
394  16 A'
395  42 STO
396  00  00
397  44 SUM
398  13  13
399  44 SUM
```

$a_{ij}h$

Eng'g Const.

θ_1+r

```
400  15  15
401  44 SUM
402  17  17
403  44 SUM
404  19  19
405  00  0
406  42 STO
407  46  46
408  42 STO
409  47  47
410  42 STO
411  48  48
412  42 STO
413  49  49
414  42 STO
415  50  50
416  43 RCL
417  14  14
418  42 STO
419  40  40
420  44 SUM
421  46  46
422  43 RCL
423  13  13
424  71 SBR
425  33 X²
426  76 LBL
427  17 B'
428  43 RCL
429  16  16
430  42 STO
431  40  40
432  44 SUM
433  46  46
434  43 RCL
435  15  15
436  71 SBR
437  33 X²
438  76 LBL
439  18 C'
440  43 RCL
441  18  18
442  42 STO
443  40  40
444  44 SUM
445  46  46
446  43 RCL
447  17  17
448  71 SBR
449  33 X²
450  76 LBL
451  19 D'
452  43 RCL
453  20  20
454  42 STO
455  40  40
456  44 SUM
457  46  46
458  43 RCL
459  19  19
460  71 SBR
461  33 X²
462  00  0
463  00  0
464  00  0
465  00  0
466  00  0
467  00  0
468  00  0
469  00  0
470  00  0
471  00  0
472  00  0
473  00  0
474  00  0
475  00  0
476  00  0
477  00  0
478  00  0
479  00  0
```

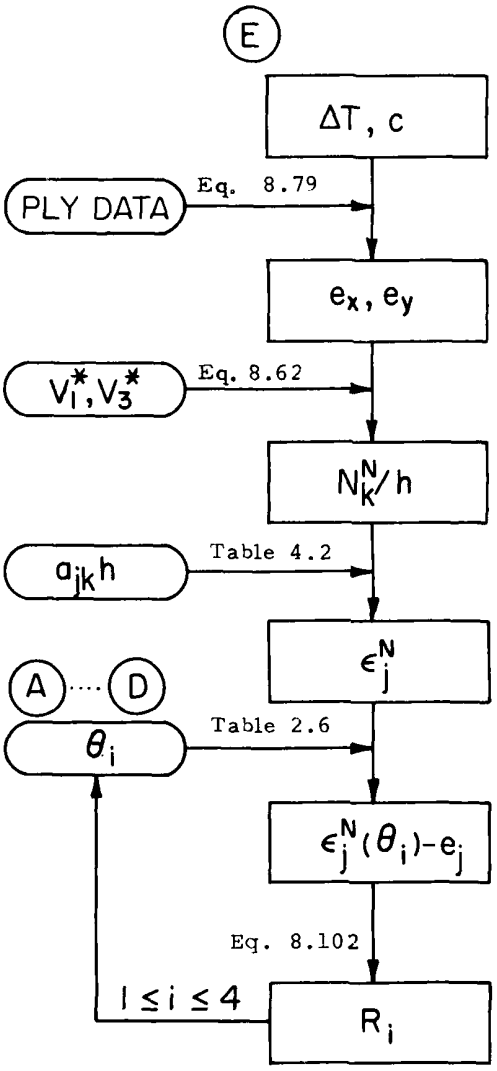
θ_2+r

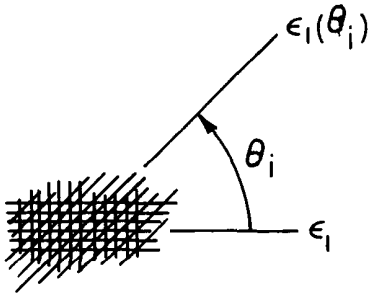
θ_3+r

θ_4+r

	0. 00	00		0. 00	00		0. 00	00		0. 00	00
	181.81114 09	01		181.81114 09	01		181.81114 09	01		181.81114 09	01
	10.346159 09	02		10.346159 09	02		10.346159 09	02		10.346159 09	02
	3.8969244 09	03		3.8969244 09	03		3.8969244 09	03		3.8969244 09	03
	0. 00	04		0. 00	04		0. 00	04		0. 00	04
	0. 00	05		0. 00	05		0. 00	05		0. 00	05
	0. 00	06		0. 00	06		0. 00	06		0. 00	06
	0. 00	07		0. 00	07		0. 00	07		0. 00	07
	0. 00	08		0. 00	08		0. 00	08		0. 00	08
	0. 00	09		0. 00	09		0. 00	09		0. 00	09
	0. 00	10		0. 00	10		0. 00	10		0. 00	10
	0. 00	11		0. 00	11		0. 00	11		0. 00	11
	0. 00	12		0. 00	12		0. 00	12		0. 00	12
θ_i	0. 00	13		45. 00	13		0. 00	13		0. 00	13
	1. 00	14		1. 00	14		1. 00	14		1. 00	14
n_i	90. 00	15		-45. 00	15		60. 00	15		90. 00	15
	1. 00	16		1. 00	16		1. 00	16		1. 00	16
	68. 06	17		68. 06	17		-60. 00	17		45. 00	17
	131. 09	18		131. 09	18		1. 00	18		1. 00	18
	10.3 09	19		10.3 09	19		10.3 09	19		-45. 00	19
	280. -03	20		280. -03	20		280. -03	20		1. 00	20
	7.17 09	21		7.17 09	21		7.17 09	21		7.17 09	21
	10. -09	22		10. -09	22		10. -09	22		10. -09	22
	12.5-06	23		12.5-06	23		12.5-06	23		12.5-06	23
	0. 00	24		0. 00	24		0. 00	24		0. 00	24
	600. -03	25		600. -03	25		600. -03	25		600. -03	25
h	500. -06	26		500. -06	26		750. -06	26		1. -03	26
	96.078649 09	27		56.657787 09	27		76.368218 09	27		76.368218 09	27
	96.078649 09	28		56.657787 09	28		76.368218 09	28		76.368218 09	28
A_{ij}/h	2.8969244 09	29		42.317787 09	29		22.607356 09	29		22.607356 09	29
	7.17 09	30		46.590862 09	30		26.880431 09	30		26.880431 09	30
	0. 00	31		0. 00	31		0. 00	31		0. 00	31
	0. 00	32		0. 00	32		0. 00	32		0. 00	32
	10.417611-12	33		39.919255-12	33		14.352198-12	33		14.352198-12	33
	10.417611-12	34		39.919255-12	34		14.352198-12	34		14.352198-12	34
$a_{ij}h$	-3814.10757-15	35		-29.815752-12	35		-4.2486946-12	35		-4.2486946-12	35
	139.47001-12	36		21.463436-12	36		37.201784-12	36		37.201784-12	36
	0. 00	37		0. 00	37		0. 00	37		0. 00	37
	0. 00	38		0. 00	38		0. 00	38		0. 00	38
	66.126864 30	39		66.126864 30	39		148.0311 30	39		148.0311 30	39
	1. 00	40		1. 00	40		1. 00	40		1. 00	40
	125. -06	41		125. -06	41		125. -06	41		125. -06	41
	49.487787 09	42		49.487787 09	42		49.487787 09	42		49.487787 09	42
	26.880431 09	43		26.880431 09	43		26.880431 09	43		26.880431 09	43
	85.73249 09	44		85.73249 09	44		85.73249 09	44		85.73249 09	44
	19.710431 09	45		19.710431 09	45		19.710431 09	45		19.710431 09	45
	2. 00	46		2. 00	46		3. 00	46		4. 00	46
	0. 00	47		0. 00	47		433.33333-15	47		0. 00	47
	1. 00	48		-1. 00	48		-733.33333-15	48		0. 00	48
	0. 00	49		0. 00	49		0. 00	49		0. 00	49
	0. 00	50		0. 00	50		0. 00	50		0. 00	50
	-3.3603243-18	51		-3.3603243-18	51		-3.3603243-18	51		-3.3603243-18	51
	0. 00	52		0. 00	52		0. 00	52		0. 00	52
	0. 00	53		0. 00	53		0. 00	53		0. 00	53
	12.004384 03	54		12.004384 03	54		12.004384 03	54		12.004384 03	54
	10.680652 03	55		10.680652 03	55		10.680652 03	55		10.680652 03	55
	-3.0691033 03	56		-3.0691033 03	56		-3.0691033 03	56		-3.0691033 03	56
	11.117842 03	57		11.117842 03	57		11.117842 03	57		11.117842 03	57
	60.646995 00	58		60.646995 00	58		60.646995 00	58		60.646995 00	58
	216.59641 00	59		216.59641 00	59		216.59641 00	59		216.59641 00	59

TAPE #4
IN-PLANE NON MECHANICAL STRAINS OF SYMMETRIC LAMINATES





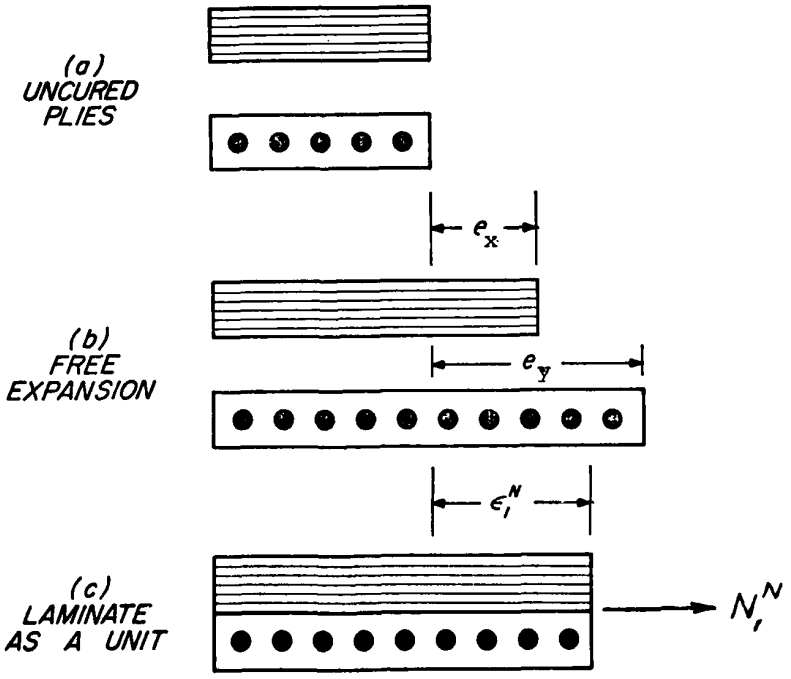
USER INSTRUCTIONS

TAPE #4: IN-PLANE NONMECHANICAL STRAINS OF SYMMETRIC LAMINATES

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
0	Data from Tape #3 must be in storage.*	--		--
1	Enter ΔT, and c and calculate ϵ_j^N	ΔT	E	ΔT
		c	R/S	1.00
2**	Calculate nonmechanical strains and the strength ratios R_i for each layer, i=1-4.	--	A	R_1
	The strengths are based on the combination of environmentally induced strains from both temperature and moisture.	--	B	R_2
		--	C	R_3
		--	D	R_4

* Data in Registers 47 and 49 are needed for this Tape.

** This step is not necessary for the strength calculations in subsequent tapes. In fact, only side 1 of this tape (program steps 000 - 166) need to be entered. The nonmechanical strength ratio indicates the temperature and/or moisture level that would induce ply failures.



Tape# 4 Title IN-PLANE NONMECHANICAL STRAINS OF SYMMETRIC LAMINATES

A'	B'	C'	D'	E'
A R_1	B R_2	C R_3	D R_4	E ΔT, c
00 γ	15 θ_2	30 R_1	45 U_3	
01 Q_{xx}	16 n_2	31 R_2	46 n	
02 Q_{yy}	17 θ_3	32 R_3	47 V^*_{1A}	
03 Q_{xy}	18 n_3	33 $a_{11}h$	48 V^*_{2A}, ΔT	
04 N^N_1/h	19 θ_4	34 $a_{22}h$	49 V^*_{3A}	
05 N^N_2/h	20 n_4	35 $a_{12}h$	50 V^*_{4A}, c	
06 N^N_6/h	21 $2\theta_i$	36 $a_{66}h$	51	
07 $e^N_1(\theta_i)-e_x$	22 α_x	37 $a_{16}h$	52 e_x	
08 $e^N_2(\theta_i)-e_y$	23 α_y	38 $a_{26}h$	53 e_y	
09 $e^N_6(\theta_i)$	24 β_x	39 ...R'_4	54 G_{xx}	
10 e^N_1	25 β_y	40 ...R_4	55 G_{yy}	
11 e^N_2	26 h	41	56 G_{xy}	
12 e^N_6	27 R'_1	42 $\frac{1}{2}(U_1+U_4)$	57 G_{ss}	
13 θ_1	28 R'_2	43 $U_5=\frac{1}{2}(U_1-U_4)$	58 G_x	
14 n_1	29 R'_3	44 U_2	59 G_y	

N_K^N/h

```
000  76 LBL
001  15  E
002  57 ENG

010  24  24
011  85  +
012  43 RCL
013  48  48
014  65  ×
015  43 RCL
016  22  22
017  95  =
018  42 STO
019  52  52
020  08  8
021  66 PAU
022  43 RCL
023  48  48
024  65  ×
025  43 RCL
026  23  23
027  85  +
028  43 RCL
029  50  50
030  65  ×
031  43 RCL
032  25  25
033  95  =
034  42 STO
035  53  53
036  65  ×
037  43 RCL
038  03  03
039  85  +
040  43 RCL
041  52  52
042  65  ×
043  43 RCL
044  01  01
045  95  =
046  42 STO
047  39  39
048  43 RCL
049  52  52
050  65  ×
051  43 RCL
052  03  03
053  85  +
054  43 RCL
055  53  53
056  65  ×
057  43 RCL
058  02  02
059  95  =
060  42 STO
061  40  40
062  85  +
063  43 RCL
064  39  39
065  95  =
066  55  -
067  02  2
068  95  =
069  42 STO
070  39  39
071  75  -
072  43 RCL
073  40  40
074  95  =
075  42 STO
076  40  40
077  65  ×
078  43 RCL
079  47  47
```

ε_j^N

```
080  85  +
081  43 RCL
082  39  39
083  95  =
084  42 STO
085  04  04
086  75  -
087  02  2
088  65  ×
089  43 RCL
090  47  47
091  65  ×
092  43 RCL
093  40  40
094  95  =
095  42 STO
096  05  05
097  43 RCL
098  49  49
099  65  ×
100  43 RCL
101  40  40
102  95  =
103  94 +/-
104  42 STO
105  06  06
106  65  ×
107  43 RCL
108  37  37
109  85  +
110  43 RCL
111  04  04
112  65  ×
113  43 RCL
114  33  33
115  85  +
116  43 RCL
117  05  05
118  65  ×
119  43 RCL
120  35  35
121  95  =
122  42 STO
123  10  10
124  43 RCL
125  04  04
126  65  ×
127  43 RCL
128  35  35
129  85  +
130  43 RCL
131  05  05
132  65  ×
133  43 RCL
134  34  34
135  85  +
136  43 RCL
137  06  06
138  65  ×
139  43 RCL
140  38  38
141  95  =
142  42 STO
143  11  11
144  43 RCL
145  04  04
146  65  ×
147  43 RCL
148  37  37
149  85  +
150  43 RCL
151  05  05
152  65  ×
153  43 RCL
154  38  38
155  85  +
156  43 RCL
157  06  06
158  65  ×
159  43 RCL
```

```
160  36  36
161  95  =
162  42 STO
163  12  12
164  01  1
165  95  =
166  91 R/S
```

R_1

```
167  76 LBL
168  11  A
169  43 RCL
170  13  13
171  71 SBR
172  35 1/X
173  42 STO
174  27  27
175  43 RCL
176  40  40
177  42 STO
178  30  30
179  91 R/S
```

R_2

```
180  76 LBL
181  12  B
182  43 RCL
183  15  15
184  71 SBR
185  35 1/X
186  42 STO
187  28  28
188  43 RCL
189  40  40
190  42 STO
191  31  31
192  91 R/S
```

R_3

```
193  76 LBL
194  13  C
195  43 RCL
196  17  17
197  71 SBR
198  35 1/X
199  42 STO
200  29  29
201  43 RCL
202  40  40
203  42 STO
204  32  32
205  91 R/S
```

R_4

```
206  76 LBL
207  14  D
208  43 RCL
209  19  19
210  71 SBR
211  35 1/X
212  42 STO
213  39  39
214  43 RCL
215  40  40
216  91 R/S
```

$\varepsilon_j^N(\theta_i) - e_j$

```
217  76 LBL
218  35 1/X
219  65  ×
220  02  2
221  95  =
222  42 STO
223  21  21
224  01  1
225  00  0
226  66 PAU
227  43 RCL
228  10  10
229  85  +
230  43 RCL
231  11  11
232  95  =
233  55  -
234  02  2
235  95  =
236  42 STO
237  39  39
238  75  -
239  43 RCL
```

Tape #4 In-Plane Nonmechanical

240	11	11	
241	95	=	
242	42	STO	
243	40	40	
244	65	×	
245	43	RCL	
246	21	21	
247	39	COS	
248	85	+	
249	43	RCL	
250	39	39	
251	85	+	
252	53	(	
253	43	RCL	
254	12	12	
255	65	×	
256	43	RCL	
257	21	21	
258	38	SIN	
259	54	)	
260	55	÷	
261	02	2	
262	75	-	
263	43	RCL	
264	52	52	
265	95	=	
266	42	STO	
267	07	07	
268	75	-	
269	43	RCL	
270	10	10	
271	75	-	
272	43	RCL	
273	11	11	
274	85	+	
275	43	RCL	
276	52	52	
277	85	+	
278	43	RCL	
279	53	53	
280	95	=	
281	94	+/-	
282	42	STO	
283	08	08	
284	43	RCL	
285	12	12	
286	65	×	
287	43	RCL	
288	21	21	
289	39	COS	
290	75	-	
291	43	RCL	
292	40	40	
293	65	×	
294	02	2	
295	65	×	
296	43	RCL	
297	21	21	
298	38	SIN	
299	95	=	
300	42	STO	
301	09	09	
302	33	X^2	
303	65	×	
304	43	RCL	R_i
305	57	57	
306	85	+	
307	43	RCL	
308	54	54	
309	65	×	
310	43	RCL	
311	07	07	
312	33	X^2	
313	85	+	
314	02	2	
315	65	×	
316	43	RCL	
317	56	56	
318	65	×	
319	43	RCL	
320	07	07	
321	65	×	
322	43	RCL	
323	08	08	
324	85	+	
325	43	RCL	
326	55	55	
327	65	×	
328	43	RCL	
329	08	08	
330	33	X^2	
331	95	=	
332	42	STO	
333	39	39	
334	43	RCL	
335	58	58	
336	65	×	
337	43	RCL	
338	07	07	
339	85	+	
340	43	RCL	
341	59	59	
342	65	×	
343	43	RCL	
344	08	08	
345	95	=	
346	55	÷	
347	43	RCL	
348	39	39	
349	55	÷	
350	02	2	
351	95	=	
352	42	STO	
353	40	40	
354	33	X^2	
355	85	+	
356	43	RCL	
357	39	39	
358	35	1/X	
359	95	=	
360	34	$\sqrt{X}$	
361	42	STO	
362	39	39	
363	75	-	
364	43	RCL	
365	40	40	
366	95	=	
367	42	STO	
368	40	40	
369	75	-	
370	02	2	
371	65	×	
372	43	RCL	
373	39	39	
374	95	=	
375	94	+/-	
376	92	RTN	

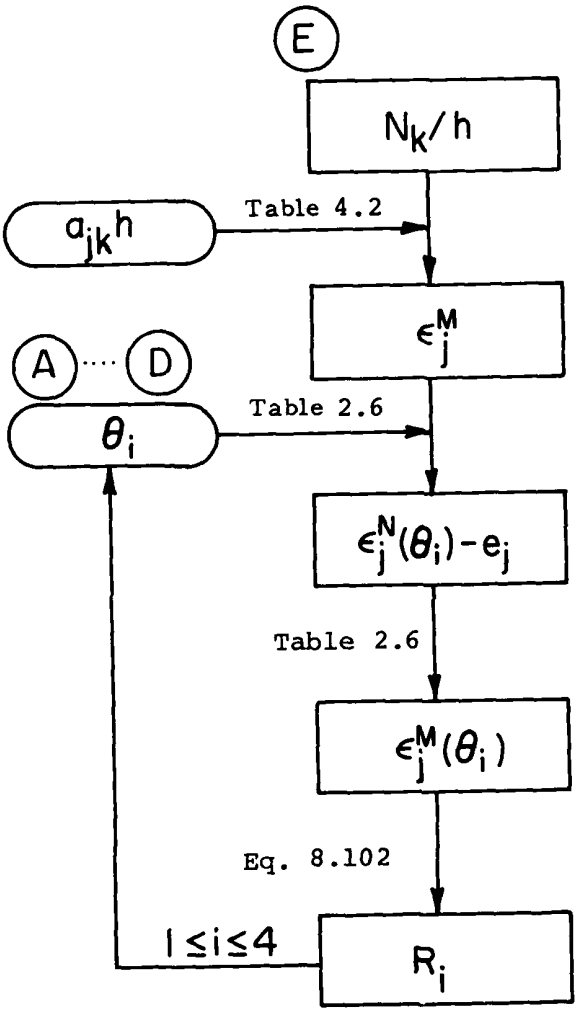
Tape #4 In-Plane Nonmechanical / sample problems

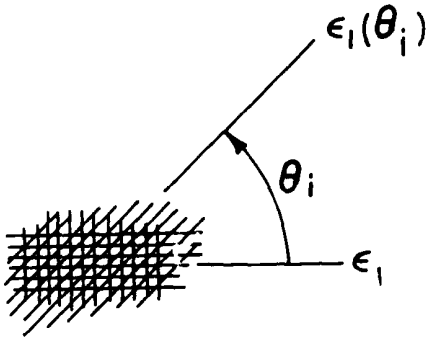
	0. 00	00
	181.81114 09	01
	10.346159 09	02
	2.8969244 09	03
	-12.553922 06	04
	-12.553922 06	05
	0. 00	06
	-125.33858-06	07
	1.7481614-03	08
	0. 00	09
	-126.83858-06	10
	-126.83858-06	11
	0. 00	12
θ_i	0. 00	13
	1. 00	14
n_i	90. 00	15
	1. 00	16
	68. 06	17
	181. 09	18
	10.3 09	19
	280. -03	20
	180. 00	21
	10. -09	22
	12.5-06	23
	0. 00	24
	600. -03	25
	500. -06	26
	13.092402 00	27
	13.092402 00	28
	2.8969244 09	29
	2.2350152 00	30
	2.2350152 00	31
	0. 00	32
	10.417611-12	33
	10.417611-12	34
	-314.10757-15	35
	139.47001-12	36
	0. 00	37
	0. 00	38
	7.6637088 00	39
	2.2350152 00	40
	125. -06	41
	49.487787 09	42
	26.880431 09	43
	85.73249 09	44
	19.710431 09	45
	2. 00	46
	0. 00	47
ΔT	-150. 00	48
	0. 00	49
c	0. 00	50
	-3.3603243-18	51
	-1.5-06	52
	-1.875-03	53
	12.004384 03	54
	10.680652 03	55
	-3.0691032 03	56
	11.117842 03	57
	60.646995 00	58
	216.59641 00	59

	0. 00	00
	181.81114 09	01
	10.346159 09	02
	2.8969244 09	03
	19.864625 06	04
	19.864625 06	05
	0. 00	06
	200.7023-06	07
	-2.7992977-03	08
	0. 00	09
	200.7023-06	10
	200.7023-06	11
	0. 00	12
	0. 00	13
	1. 00	14
	90. 00	15
	1. 00	16
	68. 06	17
	181. 09	18
	10.3 09	19
	280. -03	20
	180. 00	21
	10. -09	22
	12.5-06	23
	0. 00	24
	600. -03	25
	500. -06	26
	1.395767 00	27
	1.395767 00	28
	2.8969244 09	29
	8.1762053 00	30
	8.1762053 00	31
	0. 00	32
	10.417611-12	33
	10.417611-12	34
	-314.10757-15	35
	139.47001-12	36
	0. 00	37
	0. 00	38
	4.7859861 00	39
	8.1762053 00	40
	125. -06	41
	49.487787 09	42
	26.880431 09	43
	85.73249 09	44
	19.710431 09	45
	2. 00	46
	0. 00	47
	0. 00	48
	0. 00	49
	5. -03	50
	-3.3603243-18	51
	0. 00	52
	3. -03	53
	12.004384 03	54
	10.680652 03	55
	-3.0691032 03	56
	11.117842 03	57
	60.646995 00	58
	216.59641 00	59

	0. 00	00
	181.81114 09	01
	10.346159 09	02
	2.8969244 09	03
	7.3107032 06	04
	7.3107032 06	05
	0. 00	06
	75.363712-06	07
	-1.0511363-03	08
	0. 00	09
	73.863712-06	10
	73.863712-06	11
	0. 00	12
	0. 00	13
	1. 00	14
	90. 00	15
	1. 00	16
	68. 06	17
	181. 09	18
	10.3 09	19
	280. -03	20
	180. 00	21
	10. -09	22
	12.5-06	23
	0. 00	24
	600. -03	25
	500. -06	26
	3.7170891 00	27
	3.7170891 00	28
	2.8969244 09	29
	21.774182 00	30
	21.774182 00	31
	0. 00	32
	10.417611-12	33
	10.417611-12	34
	-314.10757-15	35
	139.47001-12	36
	0. 00	37
	0. 00	38
	12.745636 00	39
	21.774182 00	40
	125. -06	41
	49.487787 09	42
	26.880431 09	43
	85.73249 09	44
	19.710431 09	45
	2. 00	46
	0. 00	47
	-150. 00	48
	0. 00	49
	5. -03	50
	-3.3603243-18	51
	-1.5-06	52
	1.125-03	53
	12.004384 03	54
	10.680652 03	55
	-3.0691032 03	56
	11.117842 03	57
	60.646995 00	58
	216.59641 00	59

TAPE #5
IN-PLANE STRENGTH OF SYMMETRIC LAMINATES



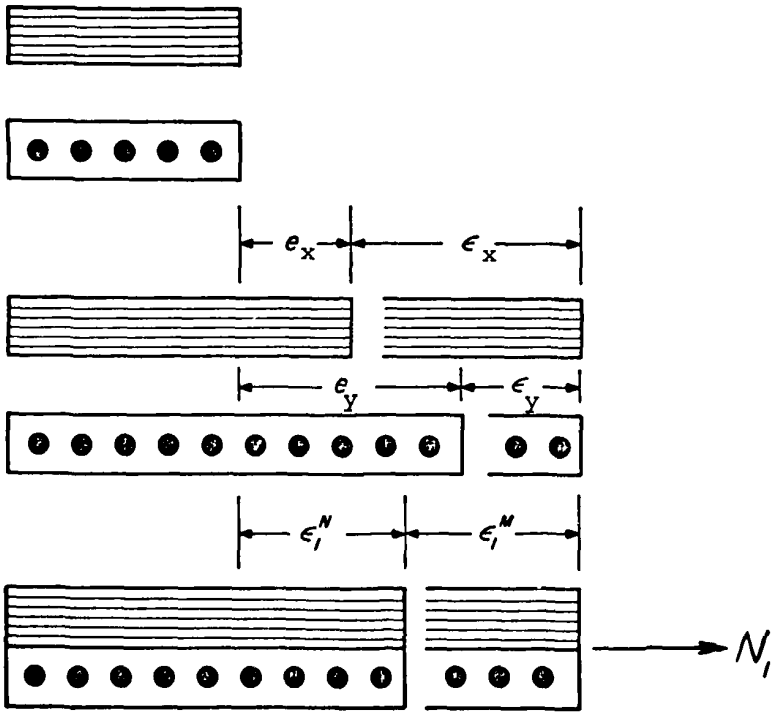


USER INSTRUCTIONS

TAPE #5: IN-PLANE STRENGTH OF SYMMETRIC LAMINATES

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
0	Results from Tape #3, or #3 and #4 must be in storage*	--		--
1	Enter N_k components and calculate e_i^M. Unit stresses such as [1,0,0] can be entered here. The resulting S values are the allowables.	N_1/h	E	N_1/h
		N_2/h	R/S	N_2/h
		N_6/h	R/S	1.00
2	Calculate strength ratios R_i & R_i' for each layer, i=1-4. These strengths are based on the ratios of mechanical strains; not the total strains.	--	A	R_1
		--	B	R_2
		--	C	R_3
		--	D	R_4

*Tape #5 can be used following Tape #3 if nonmechanical strains are neglected. Ply data tape used in Step 0 of Tape #3 automatically make $e_x=e_y=0$. Tape #4 need not be run for making $\Delta T=c=0$.



Tape# 5 Title IN-PLANE STRENGTH OF SYMMETRIC LAMINATES

A'	B'	C'	D'	E'
A R_1	B R_2	C R_3	D R_4	E N_k/h, e_j^M
00	15 θ_2	30 $e_1^N(\theta_i)-e_x$	45 R_4	
01 N_1/h	16	31 $e_2^N(\theta_i)-e_y$	46	
02 N_2/h	17 θ_3	32 $e_6^N(\theta_i)$	47 R'_1	
03 N_6/h	18	33 $a_{11}h$	48 R'_2	
04	19 θ_4	34 $a_{22}h$	49 R'_3	
05	20	35 $a_{12}h$	50 R'_4	
06	21 $2\theta_i$	36 $a_{66}h$	51	
07 e_1^M	22	37 $a_{16}h$	52 e_x	
08 e_2^M	23	38 $a_{26}h$	53 e_y	
09 e_6^M	24	39	54 G_{xx}	
10 e_1^N	25	40	55 G_{yy}	
11 e_2^N	26	41	56 G_{xy}	
12 e_6^N	27 $e_1^M(\theta_i)$	42 R_1	57 G_{ss}	
13 θ_1	28 $e_2^M(\theta_i)$	43 R_2	58 G_x	
14	29 $e_6^M(\theta_i)$	44 R_3	59 G_y	

	Step	Code	Key
N_k/h	000	76	LBL
	001	15	E
	002	57	ENG
	003	42	STO
	004	01	01
	005	91	R/S
	006	42	STO
	007	02	02
	008	91	R/S
	009	42	STO
	010	03	03
ϵ_j^M	011	65	×
	012	43	RCL
	013	37	37
	014	85	+
	015	43	RCL
	016	01	01
	017	65	×
	018	43	RCL
	019	33	33
	020	85	+
	021	43	RCL
	022	02	02
	023	65	×
	024	43	RCL
	025	35	35
	026	95	=
	027	42	STO
	028	07	07
	029	43	RCL
	030	01	01
	031	65	×
	032	43	RCL
	033	35	35
	034	85	+
	035	43	RCL
	036	03	03
	037	55	÷
	038	43	RCL
	039	34	34
	040	85	+
	041	43	RCL
	042	03	03
	043	65	×
	044	43	RCL
	045	38	38
	046	95	=
	047	42	STO
	048	08	08
	049	43	RCL
	050	01	01
	051	65	×
	052	43	RCL
	053	37	37
	054	85	+
	055	43	RCL
	056	02	02
	057	55	÷
	058	43	RCL
	059	38	38
	060	85	+
	061	43	RCL
	062	03	03
	063	65	×
	064	43	RCL
	065	36	36
	066	95	=
	067	42	STO
	068	09	09
	069	01	1
	070	95	=
	071	91	R/S
R_1	072	76	LBL
	073	11	A
	074	43	RCL
	075	13	13
	076	71	SBR
	077	35	1/X
	078	42	STO
	079	47	47
	080	43	RCL
	081	40	40
	082	42	STO
	083	42	42
	084	91	R/S
	085	43	RCL
	086	47	47
	087	91	R/S
R_2	088	76	LBL
	089	12	B
	090	43	RCL
	091	15	15
	092	71	SBR
	093	35	1/X
	094	42	STO
	095	48	48
	096	43	RCL
	097	40	40
	098	42	STO
	099	43	43
	100	91	R/S
	101	43	RCL
	102	48	48
	103	91	R/S
R_3	104	76	LBL
	105	13	C
	106	43	RCL
	107	17	17
	108	71	SBR
	109	35	1/X
	110	42	STO
	111	49	49
	112	43	RCL
	113	40	40
	114	42	STO
	115	44	44
	116	91	R/S
	117	43	RCL
	118	49	49
	119	91	R/S
R_4	120	76	LBL
	121	14	D
	122	43	RCL
	123	19	19
	124	71	SBR
	125	35	1/X
	126	42	STO
	127	50	50
	128	43	RCL
	129	40	40
	130	42	STO
	131	45	45
	132	91	R/S
	133	43	RCL
	134	50	50
	135	91	R/S
$\epsilon_j^N(\theta_i) - e_j$	136	76	LBL
	137	35	1/X
	138	65	×
	139	02	2
	140	95	=
	141	42	STO
	142	21	21
	143	01	1
	144	06	6
	145	66	PAU
	146	43	RCL
	147	10	10
	148	85	+
	149	43	RCL
	150	11	11
	151	95	=
	152	55	÷
	153	02	2
	154	95	=
	155	42	STO
	156	39	39
	157	75	-
	158	43	RCL
	159	11	11
	160	95	=
	161	42	STO
	162	40	40
	163	65	×
	164	43	RCL
	165	21	21
	166	39	COS
	167	85	+
	168	43	RCL
	169	39	39
	170	85	+
	171	43	RCL
	172	12	12
	173	65	×
	174	43	RCL
	175	21	21
	176	38	SIN
	177	55	÷
	178	02	2
	179	75	-
	180	43	RCL
	181	52	52
	182	95	=
	183	42	STO
	184	30	30
	185	75	-
	186	43	RCL
	187	10	10
	188	75	-
	189	43	RCL
	190	11	11
	191	85	+
	192	43	RCL
	193	52	52
	194	85	+
	195	43	RCL
	196	52	52
	197	95	=
	198	94	+/-
	199	42	STO
	200	31	31
	201	43	RCL
	202	12	12
	203	65	×
	204	43	RCL
	205	21	21
	206	39	COS
	207	75	-
	208	43	RCL
	209	40	40
	210	65	×
	211	02	2
	212	65	×
	213	43	RCL
	214	21	21
	215	38	SIN
	216	95	=
	217	42	STO
	218	32	32
$\epsilon_j^M(\theta_i)$	219	43	RCL
	220	07	07
	221	85	+
	222	43	RCL
	223	08	08
	224	95	=
	225	55	÷
	226	02	2
	227	95	=
	228	42	STO
	229	39	39
	230	75	-
	231	43	RCL
	232	08	08
	233	95	=
	234	42	STO
	235	40	40
	236	65	×
	237	43	RCL
	238	21	21
	239	39	COS

R_4

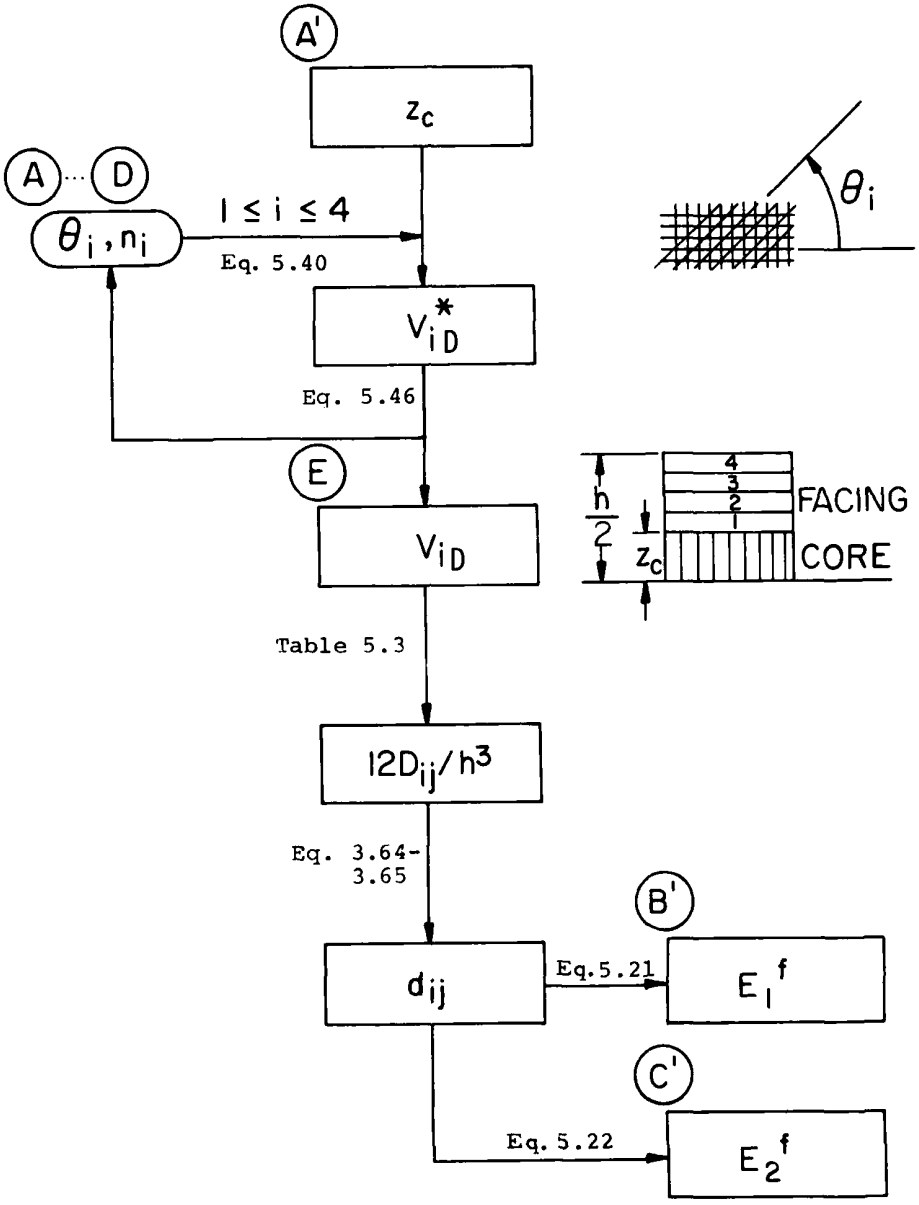
240	85	+
241	43	RCL
242	39	39
243	85	+
244	43	RCL
245	09	09
246	65	×
247	43	RCL
248	21	21
249	38	SIN
250	55	÷
251	02	2
252	95	=
253	42	STO
254	27	27
255	75	-
256	43	RCL
257	07	07
258	75	-
259	43	RCL
260	08	08
261	95	=
262	94	+/-
263	42	STO
264	28	28
265	43	RCL
266	09	09
267	85	+
268	43	RCL
269	21	21
270	38	SIN
271	75	-
272	43	RCL
273	40	40
274	65	×
275	02	2
276	65	×
277	43	RCL
278	31	31
279	38	SIN
280	95	=
281	42	STO
282	29	29
283	32	RTN
284	65	×
285	43	RCL
286	57	57
287	85	+
288	43	RCL
289	54	54
290	65	×
291	43	RCL
292	27	27
293	32	RTN
294	85	+
295	02	2
296	65	×
297	43	RCL
298	56	56
299	65	×
300	43	RCL
301	27	27
302	65	×
303	43	RCL
304	28	28
305	85	+
306	43	RCL
307	55	55
308	65	×
309	43	RCL
310	28	28
311	33	x^2
312	95	=
313	42	STO
314	39	39
315	43	RCL
316	58	58
317	65	×
318	43	RCL
319	27	27
320	85	+
321	43	RCL
322	59	59
323	65	×
324	43	RCL
325	28	28
326	85	+
327	02	2
328	65	×
329	53	(
330	43	RCL
331	54	54
332	65	×
333	43	RCL
334	27	27
335	65	×
336	43	RCL
337	30	30
338	85	+
339	43	RCL
340	56	56
341	65	×
342	53	(
343	43	RCL
344	27	27
345	65	×
346	43	RCL
347	31	31
348	85	+
349	43	RCL
350	28	28
351	55	÷
352	43	RCL
353	30	30
354	54	)
355	85	+
356	43	RCL
357	55	55
358	65	×
359	43	RCL
360	28	28
361	65	×
362	43	RCL
363	31	31
364	85	+
365	43	RCL
366	57	57
367	65	×
368	43	RCL
369	29	29
370	65	×
371	43	RCL
372	32	32
373	95	=
374	55	÷
375	43	RCL
376	39	39
377	55	÷
378	02	2
379	95	=
380	42	STO
381	40	40
382	01	1
383	75	-
384	43	RCL
385	54	54
386	65	×
387	43	RCL
388	30	30
389	33	x^2
390	75	-
391	02	2
392	65	×
393	43	RCL
394	56	56
395	65	×
396	43	RCL
397	30	30
398	65	×
399	43	RCL
400	31	31
401	75	-
402	43	RCL
403	55	55
404	65	×
405	43	RCL
406	31	31
407	33	x^2
408	75	-
409	43	RCL
410	57	57
411	65	×
412	43	RCL
413	32	32
414	33	x^2
415	75	-
416	43	RCL
417	58	58
418	65	×
419	43	RCL
420	30	30
421	75	-
422	43	RCL
423	59	59
424	65	×
425	43	RCL
426	31	31
427	95	=
428	55	÷
429	43	RCL
430	39	39
431	85	+
432	43	RCL
433	40	40
434	33	x^2
435	95	=
436	54	)
437	42	STO
438	39	39
439	75	-
440	43	RCL
441	40	40
442	95	=
443	42	STO
444	40	40
445	75	-
446	02	2
447	55	÷
448	43	RCL
449	39	39
450	95	=
451	94	+/-
452	92	RTN
453	00	0
454	00	0
455	00	0
456	00	0
457	00	0
458	00	0
459	00	0
460	00	0
461	00	0
462	00	0
463	00	0
464	00	0
465	00	0
466	00	0
467	00	0
468	00	0
469	00	0
470	00	0
471	00	0
472	00	0
473	00	0
474	00	0
475	00	0
476	00	0
477	00	0
478	00	0
479	00	0

	0. 00	0. 00	00	0. 00	0. 00 00
N_k	1. 00	1. 00	01	1. 00	1. 00 01
	0. 00	0. 00	02	0. 00	0. 00 02
	0. 00	0. 00	03	0. 00	0. 00 03
	7.3107032 06	0. 00	04	[illegible]	0. 00 04
	7.3107032 06	0. 00	05	[illegible]	0. 00 05
	0. 00	0. 00	06	0. 00	0. 00 06
	10.417611-12	10.417611-12	07	39. [illegible]	39.919255-12 07
	-314.10757-15	-314.10757-15	08	-29. [illegible]	-29.815752-12 08
	0. 00	0. 00	09	0. 00	0. 00 09
	75.863712-06	0. 00	10	75. [illegible]	0. 00 10
	75.863712-06	0. 00	11	75. [illegible]	0. 00 11
	0. 00	0. 00	12	0. 00	0. 00 12
	0. 00	0. 00	13	45. 00	45. 00 13
θ_i	1. 00	1. 00	14	1. 00	1. 00 14
m_i	90. 00	90. 00	15	-45. 00	-45. 00 15
	1. 00	1. 00	16	1. 00	1. 00 16
	68. 06	68. 06	17	68. 06	68. 06 17
	181. 09	181. 09	18	181. 09	181. 09 18
	10.3 09	10.3 09	19	10.3 09	10.3 09 19
	280. -03	280. -03	20	280. -03	280. -03 20
	180. 00	180. 00	21	-90. 00	-90. 00 21
	10. -09	10. -09	22	10. -09	10. -09 22
	12.5-06	12.5-06	23	12.5-06	12.5-06 23
	0. 00	0. 00	24	0. 00	0. 00 24
	600. -03	600. -03	25	600. -03	600. -03 25
	500. -06	500. -06	26	500. -06	500. -06 26
	-314.10757-15	-314.10757-15	27	5.0517515-12	5.0517515-12 27
	10.417611-12	10.417611-12	28	5.0517515-12	5.0517515-12 28
	0. 00	0. 00	29	69.735007-12	69.735007-12 29
	75.863712-06	0. 00	30	75.863712-06	0. 00 30
	-1.0511363-03	0. 00	31	-1.0511363-03	0. 00 31
	0. 00	0. 00	32	0. 00	0. 00 32
	10.417611-12	10.417611-12	33	39.919255-12	39.919255-12 33
	10.417611-12	10.417611-12	34	39.919255-12	39.919255-12 34
	-314.10757-15	-314.10757-15	35	-29.815752-12	-29.815752-12 35
	139.47001-12	139.47001-12	36	21.463436-12	21.463436-12 36
	0. 00	0. 00	37	0. 00	0. 00 37
	0. 00	0. 00	38	0. 00	0. 00 38
	1.3193015 09	1.3211072 09	39	149.56132 06	136.08024 06 39
	473.81212 06	373.39552 06	40	137.38862 06	123.2282 06 40
	125. -06	125. -06	41	125. -06	125. -06 41
R_k	739.83225 06	681.88201 06	42	137.38862 06	123.2282 06 42
	473.81212 06	373.39552 06	43	137.38862 06	123.2282 06 43
	85.73249 09	85.73249 09	44	85.73249 09	85.73249 09 44
	19.710431 09	19.710431 09	45	19.710431 09	19.710431 09 45
	2. 00	2. 00	46	2. 00	2. 00 46
R_i'	1.2360994 09	1.1077053 09	47	161.73402 06	148.93229 06 47
	2.1647909 09	2.2688189 09	48	161.73402 06	148.93229 06 48
	0. 00	0. 00	49	0. 00	0. 00 49
	5. -03	0. 00	50	5. -03	0. 00 50
	-3.3603243-18	-3.3603243-18	51	-3.3603243-18	-3.3603243-18 51
	-1.5-06	0. 00	52	-1.5-06	0. 00 52
	1.125-03	0. 00	53	1.125-03	0. 00 53
	12.004384 03	12.004384 03	54	12.004384 03	12.004384 03 54
	10.680652 03	10.680652 03	55	10.680652 03	10.680652 03 55
	-3.0691032 03	-3.0691032 03	56	-3.0691032 03	-3.0691032 03 56
	11.117842 03	11.117842 03	57	11.117842 03	11.117842 03 57
	60.646995 00	60.646995 00	58	60.646995 00	60.646995 00 58
	216.59641 00	216.59641 00	59	216.59641 00	216.59641 00 59

$\Delta T = -150°c$	0	-150°c	0
$e = .005$	0	.005	0

TAPE #6

FLEXURAL RIGIDITY OF SYMMETRIC SANDWICH PLATES



USER INSTRUCTIONS

TAPE #6: FLEXURAL RIGIDITY OF SYMMETRIC SANDWICH PLATES

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
0	Results from Tapes #4 for in-plane non-mechanical strains e_j^N shall be in place. Tape #6 can be used by manually inputting (θ_i, n_i^*), instead of Tape #3.	--	--	--
1	Enter core half thickness z_c and initialize z_i	z_c	A'	0.00
2	Ply angle θ_i^{**} and position z_i	--	A	$2z_1$
	for computation of V_{1D}^*, V_{2D}^*, V_{3D}^*,	--	B	$2z_2$
	and V_{4D}^* are initialized. The thickness	--	C	$2z_3$
	of the laminate up to that point is displayed.	--	D	$2z_4$
3	Calculate V_{iD}, $12D_{ij}/h^3$ and d_{ij}.	--	E	1.00
4	Calculate engineering constants		B'	E_1^f
			C'	E_2^f

* Consistent with Tape #3, n_i refers to the plies of θ_i in the upper half of the laminate.

** Ply orientations are starting from the mid plane, z=0, or the upper surface of the sandwich core, $z=z_c$; this is the opposite of the usual ply orientation code which uses an ascending order from the bottom ply, $z= -h/2$.

Tape# 6 Title FLEXURAL RIGIDITY OF SYMMETRIC SANDWICH PLATES

A' z_c, z_i	B' E_1^f	C' E_2^f	D'	E'
A θ_1	B θ_2	C θ_3	D θ_4	E D^*_{ij}, d_{ij}

00		15	θ_2	30	$12D_{66}/h^3$	45	U_3
01		16	n_2, z_2	31	$12D_{16}/h^3$	46	$1-(2z_c/h)^3$
02		17	θ_3	32	$12D_{26}/h^3$	47	
03		18	n_3, z_3	33	d_{11}	48	
04		19	θ_4	34	d_{22}	49	$2\theta_i$
05		20	n_4, $z_4=\frac{h}{2}$	35	d_{12}	50	$z_i^3-z_{i-1}^3$
06		21	z_c	36	d_{66}	51	$h/2, h^3/12$
07		22	V_{1D}	37	d_{16}	52	e_x
08		23	V_{2D}	38	d_{26}	53	e_y
09		24	V_{3D}	39	$\|D\|$	54	G_{xx}
10	e_1^N	25	V_{4D}	40		55	G_{yy}
11	e_2^N	26		41	h_o	56	G_{xy}
12	e_6^N	27	$12D_{11}/h^3$	42	$\frac{1}{2}(U_1+U_4)$	57	G_{ss}
13	θ_1	28	$12D_{22}/h^3$	43	$U_5=\frac{1}{2}(U_1-U_4)$	58	G_x
14	n_1, z_1	29	$12D_{12}/h^3$	44	U_2	59	G_y

z_i

000	76	LBL
001	15	E'
002	43	RCL
003	11	11
004	85	+
005	43	RCL
006	14	14
007	75	-
008	43	RCL
009	12	12
010	95	=
011	42	STO
012	13	13
013	01	1
014	85	+
015	43	RCL
016	15	15
017	95	=
018	42	STO
019	41	41
020	85	+
021	43	RCL
022	16	16
023	75	-
024	43	RCL
025	18	18
026	95	=
027	42	STO
028	17	17
029	43	RCL
030	20	20
031	42	STO
032	41	41
033	65	×
034	43	RCL
035	41	41
036	95	=
037	42	STO
038	40	40
039	76	LBL
040	11	A
041	42	STO
042	21	21
043	43	RCL
044	21	21
045	42	STO
046	24	24
047	42	STO
048	25	25
049	91	R/S

z_1

050	76	LBL
051	11	A
052	43	RCL
053	11	11
054	42	STO
055	31	31
056	65	×
057	02	2
058	75	-
059	43	RCL
060	31	31
061	45	Y^x
062	02	2
063	95	=
064	42	STO
065	32	32
066	43	RCL
067	13	13
068	71	SBR
069	33	33

z_2

070	76	LBL
071	12	B
072	43	RCL
073	16	16
074	42	STO
075	51	51
076	45	Y^x
077	03	3
078	75	-
079	43	RCL
080	14	14
081	45	Y^x
082	02	2
083	95	=
084	42	STO
085	50	50
086	43	RCL
087	15	15
088	71	SBR
089	34	34

z_3

090	76	LBL
091	13	C
092	43	RCL
093	11	11
094	42	STO
095	51	51
096	45	Y^x
097	03	3
098	75	-
099	43	RCL
100	16	16
101	45	Y^x
102	03	3
103	95	=
104	42	STO
105	50	50
106	43	RCL
107	11	11
108	71	SBR
109	33	33

z_4

110	76	LBL
111	14	D
112	43	RCL
113	20	20
114	42	STO
115	51	51
116	45	Y^x
117	03	3
118	75	-
119	43	RCL
120	18	18
121	45	Y^x
122	03	3
123	95	=
124	42	STO
125	50	50
126	43	RCL
127	19	19

V_{cD}^*

128	76	LBL
129	33	X^2
130	65	×
131	02	2
132	95	=
133	94	+/-
134	42	STO
135	49	49
136	39	COS
137	65	×
138	43	RCL
139	50	50
140	95	=
141	44	SUM
142	22	22
143	43	RCL
144	49	49
145	38	SIN
146	65	×
147	43	RCL
148	50	50
149	95	=
150	44	SUM
151	24	24
152	02	2
153	49	PRD
154	49	49
155	43	RCL
156	49	49
157	39	COS
158	65	×
159	43	RCL
160	50	50
161	95	=
162	44	SUM
163	23	23
164	43	RCL
165	49	49
166	38	SIN
167	65	×
168	43	RCL
169	50	50
170	95	=
171	44	SUM
172	25	25
173	43	RCL
174	51	51
175	65	×
176	02	2
177	95	=
178	91	R/S

V_{iD}

179	76	LBL
180	15	E
181	01	1
182	03	3
183	66	PAU
184	43	RCL
185	51	51
186	45	Y^x
187	03	3
188	95	=
189	35	1/x
190	49	PRD
191	23	23
192	49	PRD
193	23	23
194	49	PRD
195	24	24
196	49	PRD
197	25	25
198	65	×
199	43	RCL
200	21	21
201	45	Y^x
202	03	3
203	75	-
204	01	1
205	95	=
206	94	+/-
207	42	STO
208	46	46

$\frac{12}{h^3} D_{ij}$

209	43	RCL
210	42	42
211	85	+
212	43	RCL
213	43	43
214	95	=
215	65	×
216	43	RCL
217	46	46
218	85	+
219	43	RCL
220	22	22
221	65	×
222	43	RCL
223	44	44
224	85	+
225	43	RCL
226	23	23
227	65	×
228	43	RCL
229	45	45
230	95	=
231	42	STO
232	27	27
233	75	-
234	02	2
235	65	×
236	43	RCL
237	22	22
238	65	×
239	43	RCL

```
240  44  44
241  95  =
242  42 STO
243  28  28
244  43 RCL
245  42  42
246  75  -
247  43 RCL
248  43  43
249  95  =
250  65  ×
251  43 RCL
252  46  46
253  75  -
254  43 RCL
255  23  23
256  65  ×
257  43 RCL
258  45  45
259  95  =
260  42 STO
261  29  29
262  75  -
263  43 RCL
264  42  42
265  65  ×
266  43 RCL
267  46  46
268  85  +
269  02  2
270  65  ×
271  43 RCL
272  43  43
273  65  ×
274  43 RCL
275  46  46
276  95  =
277  42 STO
278  30  30
279  43 RCL
280  24  24
281  65  ×
282  43 RCL
283  44  44
284  55  ÷
285  02  2
286  85  +
287  43 RCL
288  25  25
289  65  ×
290  43 RCL
291  45  45
292  95  =
293  94 +/-
294  42 STO
295  31  31
296  85  +
297  02  2
298  65  ×
299  43 RCL
300  25  25
301  65  ×
302  43 RCL
303  45  45
304  95  =
305  42 STO
306  32  32
307  43 RCL
308  27  27
309  65  ×
310  43 RCL
311  28  28
312  65  ×
313  43 RCL
314  30  30
315  85  +
316  43 RCL
317  29  29
318  65  ×
319  43 RCL
```

IDI

```
320  31  31
321  65  ×
322  43 RCL
323  32  32
324  65  ×
325  02  2
326  75  -
327  43 RCL
328  28  28
329  65  ×
330  43 RCL
331  31  31
332  33  X²
333  75  -
334  43 RCL
335  27  27
336  65  ×
337  43 RCL
338  32  32
339  33  X²
340  75  -
341  43 RCL
342  30  30
343  65  ×
344  43 RCL
345  29  29
346  33  X²
347  95  =
348  42 STO
349  39  39
350  43 RCL
351  28  28
352  65  ×
353  43 RCL
354  30  30
355  75  -
356  43 RCL
357  32  32
358  33  X²
359  95  =
360  42 STO
361  33  33
362  43 RCL
363  27  27
364  65  ×
365  43 RCL
366  28  28
367  75  -
368  43 RCL
369  29  29
370  33  X²
371  95  =
372  42 STO
373  36  36
374  43 RCL
375  27  27
376  65  ×
377  43 RCL
378  30  30
379  75  -
380  43 RCL
381  31  31
382  33  X²
383  95  =
384  42 STO
385  34  34
386  43 RCL
387  29  29
388  65  ×
389  43 RCL
390  32  32
391  75  -
392  43 RCL
393  28  28
394  65  ×
395  43 RCL
396  31  31
397  95  =
398  42 STO
399  37  37
```

d_{ij}^{*}

```
400  43 RCL
401  31  31
402  65  ×
403  43 RCL
404  33  33
405  75  -
406  43 RCL
407  29  29
408  65  ×
409  43 RCL
410  30  30
411  95  =
412  42 STO
413  35  35
414  43 RCL
415  29  29
416  65  ×
417  43 RCL
418  31  31
419  75  -
420  43 RCL
421  27  27
422  65  ×
423  43 RCL
424  32  32
425  95  =
426  42 STO
427  38  38
428  43 RCL
429  51  51
430  45  YX
431  03  3
432  65  ×
433  02  2
434  55  ÷
435  03  3
436  95  =
437  42 STO
438  51  51
439  65  ×
440  43 RCL
441  39  39
442  95  =
443  35 1/X
444  49 PRD
445  33  33
446  49 PRD
447  34  34
448  49 PRD
449  35  35
450  49 PRD
451  36  36
452  49 PRD
453  37  37
454  49 PRD
455  38  38
456  01  1
457  95  =
458  91 R/S
459  76 LBL
460  17 B'
461  43 RCL
462  33  33
463  65  ×
464  43 RCL
465  51  51
466  95  =
467  35 1/X
468  91 R/S
469  76 LBL
470  18 C'
471  43 RCL
472  34  34
473  65  ×
474  43 RCL
475  51  51
476  95  =
477  35 1/X
478  91 R/S
479  00  0
```

d_{ij}

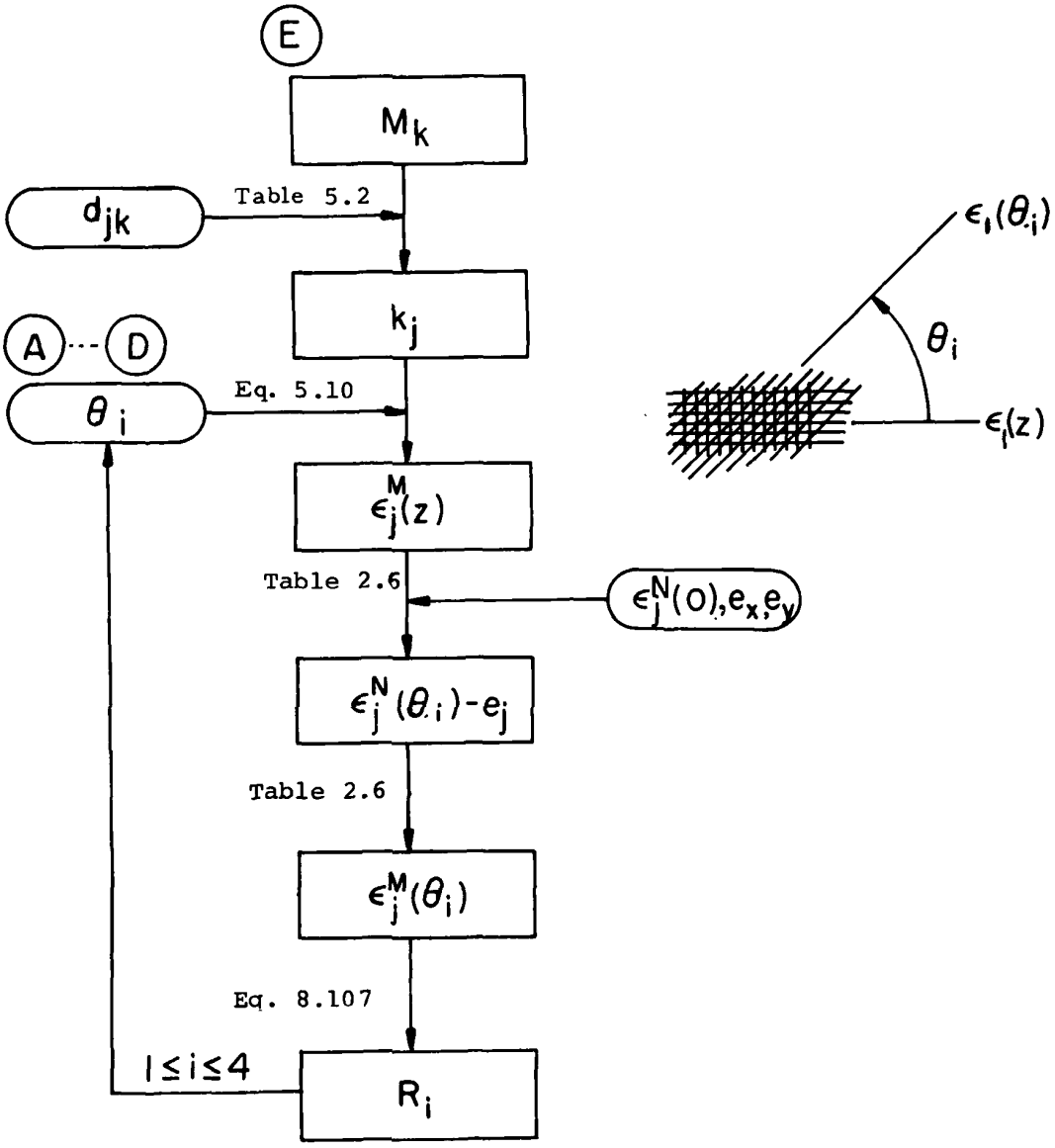
E_1^f

E_2^f

	0. 00	0. 00	0. 00	0. 00 00
	181.8 114 09	181.81114 09	181.8 114 04	181.8 114 09 01
	10.346159 09	10.346159 09	10.346159 09	10.346159 09 02
	2.8969244 09	2.8969244 09	2.8969244 09	2.8969244 09 03
	0. 00	0. 00	0. 00	0. 00 04
	0. 00	0. 00	0. 00	0. 00 05
0_8°	0. 00	0_4° 0. 00	0_4° 0. 00	0_2° 0. 00 06
	0. 00	0. 00	0. 00	90_2° 0. 00 07
	0. 00	0. 00	0. 00	0. 00 08
	0. 00	0. 00	0. 00	0. 00 09
$[0_8]_S$	0. 00	$[0_4/core_4]_S$ 0. 00	$[0_4/90_4]_S$ 0. 00	$[0_2/90_2/core]_S$ 0. 00 10
	0. 00	0. 00	0. 00	0. 00 11
	0. 00	0. 00	0. 00	0. 00 12
	0. 00	0. 00	90. 00	90. 00 13
θ_1, z_1	1. -03	1. -03	500. -06	750. -06 14
	40. 06	40. 06	0. 00	0. 00 15
	3.8447501 00	30.750001 03	θ_2, z_2 1. -03	1. -03 16
	68. 06	68. 06	68. 06	68. 06 17
	2.8354135 03	22.65575 06	2.8284126 03	22.625 06 18
	10.3 09	10.3 09	10.3 09	10.3 09 19
	5.6677823 03	22.65575 06	5.6568251 03	22.625 06 20
z_c	0. 00	500. -06	0. 00	500. -06 21
	1. 00	875. -03	750. -03	281.25-03 22
	1. 00	875. -03	1. 00	875. -03 23
	0. 00	0. 00	0. 00	0. 00 24
	0. 00	0. 00	0. 00	0. 00 25
	0. 00	0. 00	0. 00	0. 00 26
	181.8 114 09	159.00475 09	160.3 902 09	108.18108 09 27
	10.346159 09	9.0528039 09	31.774281 09	59.956555 09 28
	2.8969244 09	2.5348089 09	2.8969244 09	2.5348089 09 29
$\frac{12D_{ij}}{h^3}$	7.17 09	6.27375 09	7.17 09	6.27375 09 30
	0. 00	0. 00	0. 00	0. 00 31
	0. 00	0. 00	0. 00	0. 00 32
	9.387 720-03	9.471 318-03	9.688286-03	13.87939-03 33
	145.61107-03	166.42551-03	47.276412-03	25.042923-03 34
	-2.320442-03	-2.651 137-03	-853.99470-06	-586.78489-06 35
d_{ij}	209.20502-03	239.09145-03	209.20502-03	239.09145-03 36
	0. 00	0. 00	0. 00	0. 00 37
	0. 00	0. 00	0. 00	0. 00 38
	13.428734 30	0.3944971 30	36.483153 30	40.653267 30 39
	0. 00	0. 00	0. 00	0. 00 40
	125. -06	125. -06	125. -06	125. -06 41
	49.487787 09	49.487787 09	49.487787 09	49.487787 09 42
	26.880431 09	26.880431 09	26.880431 09	26.880431 09 43
	85.73249 09	85.73249 09	85.73249 09	85.73249 09 44
	19.710431 09	19.710431 09	19.710431 09	19.710431 09 45
$1-(\frac{z_c}{z})^3$	1. 00	875. -03	1. 00	875. -03 46
	0. 00	0. 00	0. 00	0. 00 47
	101.62602-18	101.62602-18	101.62602-18	101.62602-18 48
	0. 00	0. 00	0. 00	0. 00 49
$\frac{h^3}{12}$	1. -09	875. -12	875. -12	578.125-12 50
	666.66667-12	666.66667-12	666.66667-12	666.66667-12 51
	0. 00	0. 00	0. 00	0. 00 52
	0. 00	0. 00	0. 00	0. 00 53
	12.004384 03	12.004384 03	12.004384 03	12.004384 03 54
	10.680652 03	10.680652 03	10.680652 03	10.680652 03 55
	-3.0691032 03	-3.0691032 03	-3.0691032 03	-3.0691032 03 56
	11.117842 03	11.117842 03	11.117842 03	11.117842 03 57
	60.646995 00	60.646995 00	60.646995 00	60.646995 00 58
	216.59641 00	216.59641 00	216.59641 00	216.59641 00 59

TAPE #7

FLEXURAL STRENGTH OF SYMMETRIC SANDWICH PLATES



USER INSTRUCTION

TAPE #7: FLEXURAL STRENGTH OF SYMMETRIC SANDWICH PLATES

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
0	Results from Tape #6 must be in storage	--	--	--
1	Enter Moments M_k and calculate curvature k_j.	M_1	E	M_1
		M_2	R/S	M_2
		M_6	R/S	1.00
2	Calculate ply strains and the strength ratios at the outer face of each ply.	--	A	R_1
	These strength-strain ratios are based onmechanical strains, not the total strains.	--	B	R_2
		--	C	R_3
		--	D	R_4

Tape# 7 Title FLEXURAL STRENGTH OF SYMMETRIC SANDWICH PLATES

A'	B'	C'	D'	E'
A R_1	B R_2	C R_3	D R_4	E M_k
00	15 θ_2	30 $e_1^N(\theta_i)-e_x$	45 R_4	
01 M_1	16 z_2	31 $e_2^N(\theta_i)-e_y$	46 $1-(2z_c/h)^3$	
02 M_2	17 θ_3	32 $e_6^N(\theta_i)$	47 R'_1	
03 M_6	18 z_3	33 d_{11}	48 R'_2	
04 k_1	19 θ_4	34 d_{22}	49 R'_3	
05 k_2	20 z_4	35 d_{12}	50 θ_i, R'_4	
06 k_6	21 z_c	36 d_{66}	51 $h/2, h^3/12$	
07 $e_1^M(z)$	22	37 d_{16}	52 e_x	
08 $e_2^M(z)$	23	38 d_{26}	53 e_y	
09 $e_6^M(z)$	24	39 $\ldots R'_i$	54 G_{xx}	
10 e_1^N	25	40 $\ldots R_i$	55 G_{yy}	
11 e_2^N	26 M_6	41 h_o	56 G_{xy}	
12 e_6^N	27 $e_1^M(\theta_i)$	42 R_1	57 G_{ss}	
13 θ_1	28 $e_2^M(\theta_i)$	43 R_2	58 G_x	
14 z_1	29 $e_6^M(\theta_i)$	44 R_3	59 G_y	

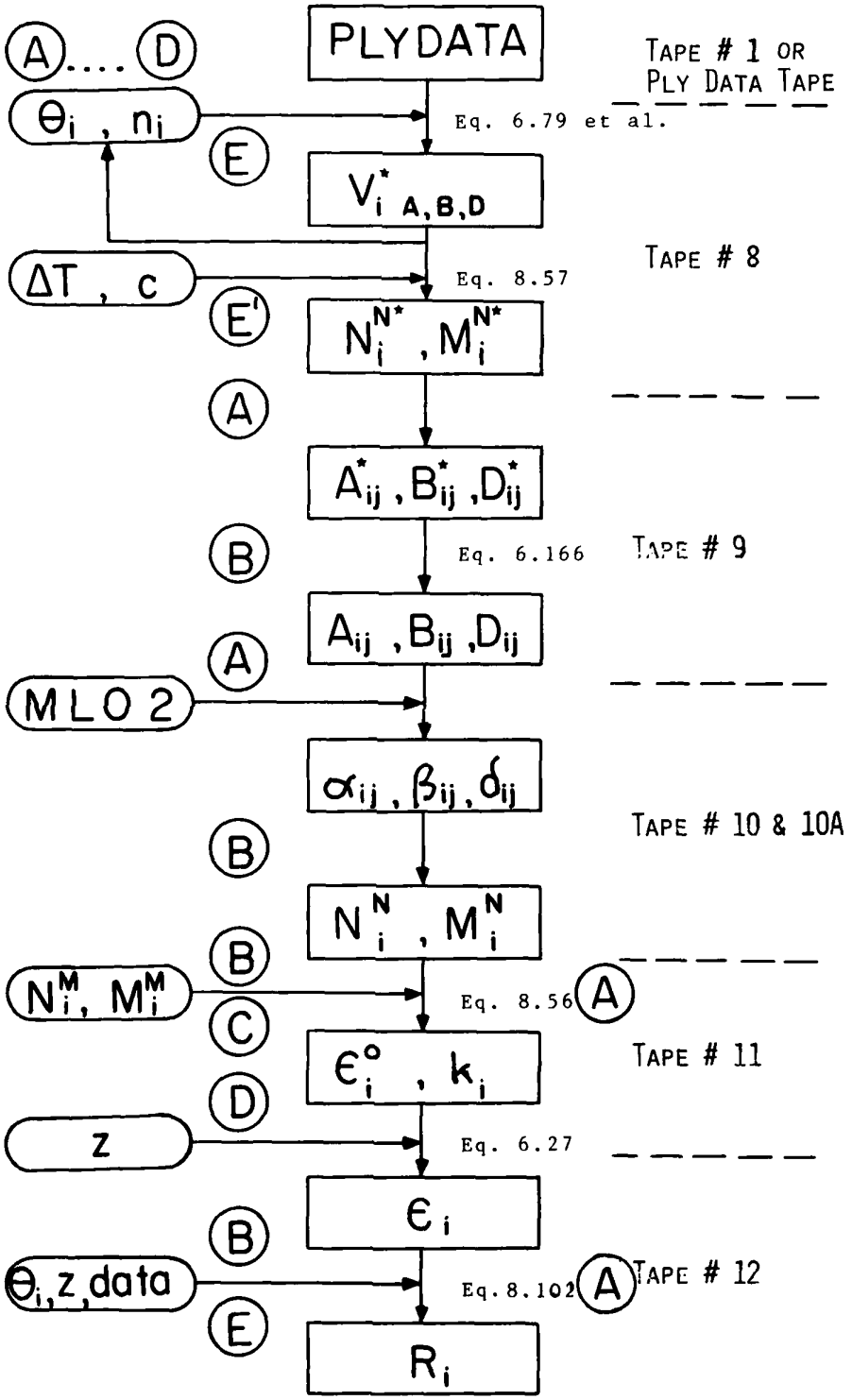
Tape #7 Flexural Strength

M_k	000	76	LBL
	001	15	E
	002	42	STO
	003	01	01
	004	91	R/S
	005	42	STO
	006	02	02
	007	91	R/S
	008	42	STO
	009	03	03
k_j	010	65	×
	011	43	RCL
	012	37	37
	013	85	+
	014	43	RCL
	015	01	01
	016	65	×
	017	43	RCL
	018	33	33
	019	85	+
	020	43	RCL
	021	02	02
	022	65	×
	023	43	RCL
	024	35	35
	025	95	=
	026	42	STO
	027	04	04
	028	43	RCL
	029	01	01
	030	65	×
	031	43	RCL
	032	35	35
	033	85	+
	034	43	RCL
	035	02	02
	036	65	×
	037	43	RCL
	038	34	34
	039	85	+
	040	43	RCL
	041	03	03
	042	65	×
	043	43	RCL
	044	38	38
	045	95	=
	046	42	STO
	047	05	05
	048	43	RCL
	049	01	01
	050	65	×
	051	43	RCL
	052	37	37
	053	85	+
	054	43	RCL
	055	02	02
	056	65	×
	057	43	RCL
	058	38	38
	059	85	+
	060	43	RCL
	061	03	03
	062	65	×
	063	43	RCL
	064	36	36
	065	95	=
	066	42	STO
	067	06	06
	068	01	1
	069	95	=
	070	91	R/S
R_1	071	76	LBL
	072	11	A
	073	43	RCL
	074	13	13
	075	42	STO
	076	50	50
	077	43	RCL
	078	14	14
	079	71	SBR
	080	35	1/X
	081	42	STO
	082	47	47
	083	43	RCL
	084	40	40
	085	42	STO
	086	42	42
	087	91	R/S
R_2	088	76	LBL
	089	12	B
	090	43	RCL
	091	15	15
	092	42	STO
	093	50	50
	094	43	RCL
	095	16	16
	096	71	SBR
	097	35	1/X
	098	42	STO
	099	48	48
	100	43	RCL
	101	40	40
	102	42	STO
	103	43	43
	104	91	R/S
R_3	105	76	LBL
	106	13	C
	107	43	RCL
	108	17	17
	109	42	STO
	110	50	50
	111	43	RCL
	112	18	18
	113	71	SBR
	114	35	1/X
	115	42	STO
	116	49	49
	117	43	RCL
	118	40	40
	119	42	STO
	120	44	44
	121	91	R/S
R_4	122	76	LBL
	123	14	D
	124	43	RCL
	125	19	19
	126	42	STO
	127	50	50
	128	43	RCL
	129	20	20
	130	71	SBR
	131	35	1/X
	132	42	STO
	133	50	50
	134	43	RCL
	135	40	40
	136	42	STO
	137	45	45
	138	91	R/S
$\epsilon_j^M(z_i)$	139	76	LBL
	140	35	1/X
	141	42	STO
	142	40	40
	143	65	×
	144	43	RCL
	145	04	04
	146	95	=
	147	42	STO
	148	07	07
	149	01	1
	150	09	9
	151	66	PAU
	152	43	RCL
	153	40	40
	154	65	×
	155	43	RCL
	156	05	05
	157	95	=
	158	42	STO
	159	08	08
	160	43	RCL
	161	40	40
	162	65	×
	163	43	RCL
	164	06	06
	165	95	=
	166	42	STO
	167	09	09
$\epsilon_j^N(\theta_i) - e_j$	168	02	2
	169	49	PRD
	170	50	50
	171	43	RCL
	172	10	10
	173	85	+
	174	43	RCL
	175	11	11
	176	95	=
	177	55	-
	178	02	2
	179	95	=
	180	42	STO
	181	39	39
	182	75	-
	183	43	RCL
	184	11	11
	185	95	=
	186	42	STO
	187	40	40
	188	65	×
	189	43	RCL
	190	50	50
	191	39	COS
	192	85	+
	193	43	RCL
	194	39	39
	195	85	+
	196	43	RCL
	197	12	12
	198	65	×
	199	43	RCL
	200	50	50
	201	38	SIN
	202	55	-
	203	02	2
	204	75	-
	205	43	RCL
	206	52	52
	207	95	=
	208	42	STO
	209	30	30
	210	75	-
	211	02	2
	212	65	×
	213	43	RCL
	214	39	39
	215	85	+
	216	43	RCL
	217	52	52
	218	85	+
	219	43	RCL
	220	53	53
	221	95	=
	222	94	+/-
	223	42	STO
	224	31	31
	225	43	RCL
	226	12	12
	227	65	×
	228	43	RCL
	229	50	50
	230	39	COS
	231	75	-
	232	43	RCL
	233	40	40
	234	65	×
	235	02	2
	236	65	×
	237	43	RCL
	238	50	50
	239	38	SIN

240	95	=
241	42	STO
242	32	32
243	43	RCL
244	07	07
245	85	+
246	43	RCL
247	08	08
248	95	=
249	55	÷
250	02	2
251	95	=
252	42	STO
253	39	39
254	75	-
255	43	RCL
256	08	08
257	95	=
258	42	STO
259	40	40
260	65	×
261	43	RCL
262	50	50
263	39	COS
264	85	+
265	43	RCL
266	39	39
267	85	+
268	43	RCL
269	09	09
270	65	×
271	43	RCL
272	50	50
273	38	SIN
274	55	÷
275	02	2
276	95	=
277	42	STO
278	27	27
279	75	-
280	43	RCL
281	07	07
282	75	-
283	43	RCL
284	08	08
285	95	=
286	94	+/-
287	42	STO
288	28	28
289	43	RCL
290	09	09
291	65	×
292	43	RCL
293	50	50
294	39	COS
295	75	-
296	43	RCL
297	40	40
298	65	×
299	02	2
300	65	×
301	43	RCL
302	50	50
303	38	SIN
304	95	=
305	42	STO
306	29	29
307	33	X^2
308	65	×
309	43	RCL
310	57	57
311	85	+
312	43	RCL
313	54	54
314	65	×
315	43	RCL
316	27	27
317	33	X^2
318	85	+
319	02	2
320	65	×
321	43	RCL
322	56	56
323	65	×
324	43	RCL
325	27	27
326	65	×
327	43	RCL
328	28	28
329	85	+
330	43	RCL
331	55	55
332	65	×
333	43	RCL
334	28	28
335	33	X^2
336	95	=
337	42	STO
338	39	39
339	43	RCL
340	58	58
341	65	×
342	43	RCL
343	27	27
344	85	+
345	43	RCL
346	59	59
347	65	×
348	43	RCL
349	28	28
350	85	+
351	02	2
352	65	×
353	53	(
354	43	RCL
355	54	54
356	65	×
357	43	RCL
358	27	27
359	65	×
360	43	RCL
361	30	30
362	85	+
363	43	RCL
364	56	56
365	65	×
366	53	(
367	43	RCL
368	27	27
369	65	×
370	43	RCL
371	31	31
372	85	+
373	43	RCL
374	28	28
375	65	×
376	43	RCL
377	30	30
378	54	)
379	85	+
380	43	RCL
381	55	55
382	65	×
383	43	RCL
384	28	28
385	65	×
386	43	RCL
387	31	31
388	85	+
389	43	RCL
390	57	57
391	65	×
392	43	RCL
393	29	29
394	65	×
395	43	RCL
396	32	32
397	95	=
398	55	÷
399	43	RCL
400	39	39
401	55	÷
402	02	2
403	95	=
404	42	STO
405	40	40
406	01	1
407	75	-
408	43	RCL
409	54	54
410	65	×
411	43	RCL
412	30	30
413	33	X^2
414	75	-
415	02	2
416	65	×
417	43	RCL
418	56	56
419	65	×
420	43	RCL
421	30	30
422	65	×
423	43	RCL
424	31	31
425	75	-
426	43	RCL
427	55	55
428	65	×
429	43	RCL
430	31	31
431	33	X^2
432	75	-
433	43	RCL
434	57	57
435	65	×
436	43	RCL
437	32	32
438	33	X^2
439	75	-
440	43	RCL
441	58	58
442	65	×
443	43	RCL
444	30	30
445	75	-
446	43	RCL
447	59	59
448	65	×
449	43	RCL
450	31	31
451	95	=
452	55	÷
453	43	RCL
454	39	39
455	85	+
456	43	RCL
457	40	40
458	33	X^2
459	95	=
460	34	$\sqrt{x}$
461	42	STO
462	39	39
463	75	-
464	43	RCL
465	40	40
466	95	=
467	42	STO
468	40	40
469	75	-
470	02	2
471	65	×
472	43	RCL
473	39	39
474	95	=
475	94	+/-
476	92	RTN
477	00	0
478	00	0
479	00	0

	0. 00	0. 00	0. 00	0. 00	00
M_K	1. 00	1. 00	1. 00	1. 00	01
	0. 00	0. 00	0. 00	0. 00	02
	0. 00	0. 00	0. 00	0. 00	03
	8.2872928-03	9.4711918-03	9.3683286-03	10.87939-03	04
	-2.320442-03	-2.6519037-03	-853.99478-06	-586.78489-06	05
	0. 00	0. 00	0. 00	0. 00	06
	8.2872928-06	9.4711918-06	9.3683286-06	10.87939-06	07
	-2.320442-06	-2.6519037-06	-853.99478-09	-586.78489-09	08
	0. 00	0. 00	0. 00	0. 00	09
	0. 00	0. 00	0. 00	0. 00	10
	0. 00	0. 00	0. 00	0. 00	11
	0. 00	0. 00	0. 00	0. 00	12
	0. 00	0. 00	90. 00	90. 00	13
	1. -03	1. -03	500. -06	750. -06	14
	40. 06	40. 06	0. 00	0. 00	15
	3.8447501 00	30.750001 03	1. -03	1. -03	16
	68. 06	68. 06	68. 06	68. 06	17
	2.8358135 03	22.65575 06	22.625 06	22.625 06	18
	10.3 09	10.3 09	10.3 09	10.3 09	19
	5.6677823 03	22.65575 06	22.625 06	22.625 06	20
	0. 00	500. -06	0. 00	500. -06	21
	1. 00	875. -03	750. -03	281.25-03	22
	1. 00	875. -03	1. 00	875. -03	23
	0. 00	0. 00	0. 00	0. 00	24
	0. 00	0. 00	0. 00	0. 00	25
	0. 00	0. 00	0. 00	0. 00	26
	8.2872928-06	9.4711918-06	9.3683286-06	10.87939-06	27
	-2.320442-06	-2.6519037-06	-853.99478-09	-586.78489-09	28
	0. 00	0. 00	0. 00	0. 00	29
	0. 00	0. 00	0. 00	0. 00	30
	0. 00	0. 00	0. 00	0. 00	31
	0. 00	0. 00	0. 00	0. 00	32
	8.2872928-03	9.4711918-03	9.3683286-03	10.87939-03	33
	145.63107-03	166.43551-03	47.278412-03	25.042923-03	34
	-2.320442-03	-2.6519037-03	-853.99478-06	-586.78489-06	35
	209.20502-03	239.09145-03	209.20502-03	239.09145-03	36
	0. 00	0. 00	0. 00	0. 00	37
	0. 00	0. 00	0. 00	0. 00	38
	1. 03	875. 00	964.5143 00	667.40582 00	39
	1. 03	875. 00	791.97978 00	516.39171 00	40
	125. -06	125. -06	125. -06	125. -06	41
R	1. 03	875. 00	835.69432 00	374.19028 00	42
	26.880431 09	26.880431 09	791.97978 00	516.39171 00	43
	85.73249 09	85.73249 09	85.73249 09	85.73249 09	44
	19.710431 09	19.710431 09	19.710431 09	19.710431 09	45
	1. 00	875. -03	1. 00	875. -03	46
R'	1. 03	875. 00	4.8092482 03	2.2499333 03	47
	101.62602-18	101.62602-18	1.1370488 03	818.41992 00	48
	0. 00	0. 00	0. 00	0. 00	49
	0. 00	0. 00	0. 00	0. 00	50
	666.66667-12	666.66667-12	666.66667-12	666.66667-12	51
	0. 00	0. 00	0. 00	0. 00	52
	0. 00	0. 00	0. 00	0. 00	53
	12.004384 03	12.004384 03	12.004384 03	12.004384 03	54
	10.680652 03	10.680652 03	10.680652 03	10.680652 03	55
	-3.0691032 03	-3.0691032 03	-3.0691032 03	-3.0691032 03	56
	11.117842 03	11.117842 03	11.117842 03	11.117842 03	57
	60.646995 00	60.646995 00	60.646995 00	60.646995 00	58
	216.59641 00	216.59641 00	216.59641 00	216.59641 00	59

TAPE # 8 - 12 GENERAL LAMINATES



USER INSTRUCTION

TAPE #8: THE V'S AND NONMECHANICAL FORCES OF GENERAL LAMINATES

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
0	Ply data must be in storage.			
1	Enter total number plies.	n	A	0
2	Enter ply angle θ_i, and number of plies at that angle n_i.	θ_1	R/S	θ_1
		n_1	R/S	V_{4D_1}
		θ_2	B	$(-\frac{n}{2}+n_1)$
		n_2	R/S	V_{4D_2}
		θ_3	C	$(-\frac{n}{2}+n_1+n_2)$
		n_3	R/S	V_{4D_3}
		θ_4	D	$(-\frac{n}{2}+n_1+n_2+n_3)$
		n_4	R/S	V_{4D_4}
		θ_5	B**	$(-\frac{n}{2}+n_1+\ldots)$
		.	.	.
		.	.	.
		.	.	
3	Calculate V^*_{ij}		E	$4/n^3$
4	Calculate N_i^{N*}, M_i^{N*}	ΔT	E'	ΔT
		c	R/S	M_6^{N*}

**Additional plies can be entered through B, C, or D key. Key A cannot be used for this purpose because it initializes the summation process.

Tape# 8 Title THE V'S AND NONMECHANICAL FORCES OF GENERAL LAMINATES

A'	B'	C'	D'	E' ΔT, c
A n, θ_1, n_1	B θ_2, n_2	C θ_3, n_3	D θ_4, n_4	E V_i^*

00	θ_1	15	$1/n^2$	30	Q_{ss}	45	U_3
01	n_1	16	$4/n^3$	31	V_{1A}^*	46	$-n/2$
02	θ_2	17	h	32	V_{2A}^*	47	V_{3D}^*
03	n_2	18	E_x	33	V_{3A}^*	48	V_{4D}^*
04	θ_3	19	E_y	34	V_{4A}^*	49	$2\theta_i$
05	n_3	20	ν_x	35	V_{1B}^*	50	$4\theta_i$
06	θ_4	21	E_s	36	V_{2B}^*	51	N_1^{N*}
07	n_4, ΔT	22	α_x	37	V_{3B}^*	52	N_2^{N*}
08	c	23	α_y	38	V_{4B}^*	53	N_6^{N*}
09	$1/n$	24	β_x	39	V_{1D}^*	54	M_1^{N*}
10	n_{i+1}, p^N	25	β_y	40	V_{2D}^*	55	M_2^{N*}
11	n_i, q^N	26	n	41	h_o	56	M_6^{N*}
12	$n_{i+1} - n_i$	27	Q_{xx}	42	$\frac{1}{2}(U_1+U_4)$	57	e_x
13	$n_{i+1}^2 - n_i^2$	28	Q_{yy}	43	$U_5=\frac{1}{2}(U_1-U_4)$	58	e_y
14	$n_{i+1}^3 - n_i^3$	29	Q_{xy}	44	U_2	59	G_y

Tape # 8 V's and Nonmechanical Forces

n	000	76	LBL		080	43	RCL		160	06	06
	001	11	A		081	17	17		161	71	SBR
	002	57	ENG		082	45	Y^x		162	33	X²
	003	42	STO		083	03	3	Δ	163	76	LBL
	004	26	26		084	95	=		164	89	π
	005	99	PRT		085	35	1/x		165	43	RCL
	006	55	÷		086	65	×		166	10	10
	007	02	2		087	04	4		167	75	-
	008	95	=		088	95	=		168	43	RCL
	009	94	+/-		089	49	PRD		169	11	11
	010	42	STO		090	16	16		170	95	=
	011	46	46		091	71	SBR		171	42	STO
	012	42	STO		092	89	π		172	12	12
	013	11	11		093	43	RCL		173	43	RCL
	014	00	0		094	00	00		174	10	10
	015	49	PRD		095	71	SBR		175	33	X²
	016	47	47		096	33	X²		176	75	-
	017	49	PRD		097	91	R/S		177	43	RCL
	018	48	48	θ_2, n_2	098	76	LBL		178	11	11
	019	49	PRD		099	12	B		179	33	X²
	020	31	31		100	42	STO		180	95	=
	021	49	PRD		101	02	02		181	42	STO
	022	32	32		102	99	PRT		182	13	13
	023	49	PRD		103	43	RCL		183	43	RCL
	024	33	33		104	10	10		184	10	10
	025	49	PRD		105	42	STO		185	33	X²
	026	34	34		106	11	11		186	65	×
	027	49	PRD		107	91	R/S		187	43	RCL
	028	35	35		108	42	STO		188	10	10
	029	49	PRD		109	03	03		189	75	-
	030	36	36		110	99	PRT		190	53	(
	031	49	PRD		111	44	SUM		191	43	RCL
	032	37	37		112	10	10		192	11	11
	033	49	PRD		113	71	SBR		193	33	X²
	034	38	38		114	89	π		194	65	×
	035	49	PRD		115	43	RCL		195	43	RCL
	036	39	39		116	02	02		196	11	11
	037	49	PRD		117	71	SBR		197	54	)
	038	40	40		118	33	X²		198	95	=
	039	91	R/S		119	91	R/S		199	42	STO
	040	99	PRT	θ_3, n_3	120	76	LBL		200	14	14
	041	42	STO		121	13	C		201	92	RTN
θ_1, n_1	042	00	00		122	42	STO		202	76	LBL
	043	91	R/S		123	04	04	V_i	203	33	X²
	044	99	PRT		124	99	PRT		204	65	×
	045	42	STO		125	43	RCL		205	02	2
	046	01	01		126	10	10		206	95	=
	047	85	+		127	42	STO		207	42	STO
	048	43	RCL		128	11	11		208	49	49
	049	46	46		129	91	R/S		209	65	×
	050	95	=		130	42	STO		210	02	2
	051	42	STO		131	05	05		211	95	=
	052	10	10		132	99	PRT		212	42	STO
	053	43	RCL		133	44	SUM		213	50	50
	054	41	41		134	10	10		214	43	RCL
	055	42	STO		135	71	SBR		215	49	49
	056	09	09		136	89	π		216	39	COS
	057	33	X²		137	43	RCL		217	65	×
	058	42	STO		138	04	04		218	43	RCL
	059	15	15		139	71	SBR		219	12	12
	060	65	×		140	33	X²		220	95	=
	061	43	RCL		141	91	R/S		221	44	SUM
	062	41	41	θ_4, n_4	142	76	LBL		222	31	31
	063	95	=		143	14	D		223	43	RCL
	064	42	STO		144	42	STO		224	50	50
	065	16	16		145	06	06		225	39	COS
	066	43	RCL		146	99	PRT		226	65	×
	067	41	41		147	43	RCL		227	43	RCL
	068	65	×		148	10	10		228	12	12
	069	43	RCL		149	42	STO		229	95	=
	070	26	26		150	11	11		230	44	SUM
	071	95	=		151	91	R/S		231	32	32
	072	42	STO		152	42	STO		232	43	RCL
	073	17	17		153	07	07		233	49	49
	074	35	1/x		154	99	PRT		234	38	SIN
	075	49	PRD		155	44	SUM		235	65	×
	076	04	04		156	10	10		236	43	RCL
	077	33	X²		157	71	SBR		237	12	12
	078	49	PRD		158	89	π		238	95	=
	079	15	15		159	43	RCL		239	44	SUM

```
239  44 SUM
240  38  38
241  43 RCL
242  50  50
243  38 SIN
244  65  ×
245  43 RCL
246  12  12
247  95  =
248  44 SUM
249  34  34
250  43 RCL
251  49  49
252  39 COS
253  65  ×
254  43 RCL
255  13  13
256  95  =
257  44 SUM
258  35  35
259  43 RCL
260  50  50
261  39 COS
262  65  ×
263  43 RCL
264  13  13
265  95  =
266  44 SUM
267  36  36
268  43 RCL
269  49  49
270  38 SIN
271  65  ×
272  43 RCL
273  13  13
274  95  =
275  44 SUM
276  37  37
277  43 RCL
278  50  50
279  38 SIN
280  65  ×
281  43 RCL
282  13  13
283  95  =
284  44 SUM
285  38  38
286  43 RCL
287  49  49
288  39 COS
289  65  ×
290  43 RCL
291  14  14
292  95  =
293  44 SUM
294  39  39
295  43 RCL
296  50  50
297  39 COS
298  65  ×
299  43 RCL
300  14  14
301  95  =
302  44 SUM
303  40  40
304  43 RCL
305  49  49
306  38 SIN
307  65  ×
308  43 RCL
309  14  14
310  95  =
311  44 SUM
312  47  47
313  43 RCL
314  50  50
315  38 SIN
316  65  ×
317  43 RCL
318  14  14
319  95  =
```

$V^{*}_{i,A,B,D}$

```
320  44 SUM
321  48  48
322  92 RTN
323  76 LBL
324  15  E
325  43 RCL
326  09  09
327  49 PRD
328  31  31
329  49 PRD
330  32  32
331  49 PRD
332  33  33
333  49 PRD
334  34  34
335  43 RCL
336  15  15
337  49 PRD
338  35  35
339  49 PRD
340  36  36
341  49 PRD
342  37  37
343  49 PRD
344  38  38
345  43 RCL
346  16  16
347  49 PRD
348  39  39
349  49 PRD
350  40  40
351  49 PRD
352  47  47
353  49 PRD
354  48  48
355  91 R/S
356  76 LBL
357  10 E'
358  42 STO
359  07  07
360  99 PRT
361  91 R/S
362  42 STO
363  08  08
364  99 PRT
365  65  ×
366  43 RCL
367  24  24
368  85  +
369  43 RCL
370  07  07
371  65  ×
372  43 RCL
373  22  22
374  95  =
375  42 STO
376  57  57
377  43 RCL
378  07  07
379  65  ×
380  43 RCL
381  23  23
382  85  +
383  43 RCL
384  08  08
385  65  ×
386  43 RCL
387  25  25
388  95  =
389  42 STO
390  58  58
391  65  ×
392  43 RCL
393  29  29
394  85  +
395  43 RCL
396  57  57
397  65  ×
398  43 RCL
399  27  27
```

N^{N*}_{i}

M^{N*}_{i}

```
400  95  =
401  42 STO
402  10  10
403  43 RCL
404  57  57
405  65  ×
406  43 RCL
407  29  29
408  95  +
409  43 RCL
410  58  58
411  65  ×
412  43 RCL
413  28  28
414  95  =
415  42 STO
416  11  11
417  85  +
418  43 RCL
419  10  10
420  95  =
421  55  -
422  02  2
423  95  =
424  42 STO
425  10  10
426  75  -
427  43 RCL
428  11  11
429  95  =
430  42 STO
431  11  11
432  65  ×
433  43 RCL
434  31  31
435  85  +
436  43 RCL
437  10  10
438  95  =
439  42 STO
440  51  51
441  75  -
442  02  2
443  65  ×
444  43 RCL
445  31  31
446  65  ×
447  43 RCL
448  11  11
449  95  =
450  42 STO
451  52  52
452  43 RCL
453  33  33
454  65  ×
455  43 RCL
456  11  11
457  95  =
458  42 STO
459  53  53
460  43 RCL
461  11  11
462  65  ×
463  43 RCL
464  35  35
465  95  =
466  42 STO
467  54  54
468  94 +-
469  42 STO
470  55  55
471  43 RCL
472  11  11
473  65  ×
474  43 RCL
475  37  37
476  95  =
477  42 STO
478  56  56
479  91 R/S
```

$[+45_8 / -45_8]_T$

```
          16.  00
          45.  00
           8.  00
         -45.  00
           8.  00
        -150.  00
           5. -03
```

```
          45.  00   00
           8.  00   01
         -45.  00   02
           8.  00   03
           0.  00   04
           0.  00   05
         -45.  00   06
ΔT     -150.  00   07
c         5. -03   08
        62.5-03    09
 7.3107032 06      10
-4.3243799 06      11
           8.  00  12
          64.  00  13
         512.  00  14
   3.90625-03      15
 976.5625-06       16
           2. -03  17
         181.  09  18
        10.3 09    19
         280. -03  20
        7.17 09    21
         10. -09   22
        12.5-06    23
           0.  00  24
         600. -03  25
          16.  00  26
 181.81114 09      27
 10.346159 09      28
 2.8969244 09      29
        7.17 09    30
           0.  00  31
          -1.  00  32
           0.  00  33
           0.  00  34
           0.  00  35
           0.  00  36
        -500. -03  37
           0.  00  38
           0.  00  39
          -1.  00  40
         125. -06  41
 49.487787 09      42
 26.880431 09      43
  85.73249 09      44
 19.710431 09      45
          -8.  00  46
           0.  00  47
           0.  00  48
         -90.  00  49
        -180.  00  50
 7.3107032 06      51
 7.3107032 06      52
           0.  00  53
           0.  00  54
           0.  00  55
  2.16219 06       56
        -1.5-06    57
       1.125-03    58
216.59641 00       59
```

$[0_8 / 90_8]_T$

```
          16.  00
           0.  00
           8.  00
          90.  00
           8.  00
        -150.  00
           5. -03
```

```
           0.      00
           8.      01
          90.      02
           8.      03
           0.  00  04
           0.  00  05
          90.  00  06
        -150.  00  07
           5. -03  08
        62.5-03    09
 7.3107032 06      10
-4.3243799 06      11
           8.  00  12
          64.  00  13
         512.  00  14
   3.90625-03      15
 976.5625-06       16
           2. -03  17
         181.  09  18
        10.3 09    19
         280. -03  20
        7.17 09    21
         10. -09   22
        12.5-06    23
           0.  00  24
         600. -03  25
          16.  00  26
 181.81114 09      27
 10.346159 09      28
 2.8969244 09      29
        7.17 09    30
           0.  00  31
           1.  00  32
           0.  00  33
           0.  00  34
        -500. -03  35
           0.  00  36
           0.  00  37
           0.  00  38
           0.  00  39
           1.  00  40
         125. -06  41
 49.487787 09      42
 26.880431 09      43
  85.73249 09      44
 19.710431 09      45
          -8.  00  46
           0.  00  47
           0.  00  48
         180.  00  49
         360.  00  50
 7.3107032 06      51
 7.3107032 06      52
           0.  00  53
  .16219 06        54
-2.16219 06        55
           0.  00  56
        -1.5-06    57
       1.125-03    58
216.59641 00       59
```

USER INSTRUCTIONS

TAPE #9: MODULUS OF GENERAL LAMINATES

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
0	Results of Tape #8 are in storage.			
1	Calculate A^*_{ij}, B^*_{ij}, D^*_{ij}		A	D^*_{26}
2*	Calculate A_{ij}, B_{ij}, D_{ij}		B	D_{26}

* This is a necessary step before the matrix inversion in Tape #10. Inversion of the normalized modulus in Step 1 is not meaningful.

Tape# 9 Title MODULUS OF GENERAL LAMINATES

A'	B'	C'	D'	E'
$A^*_{ij}, B^*_{ij}, D^*_{ij}$	A_{ij}, B_{ij}, D_{ij}	C	D	E

00	θ_1	15	A_{16}	30	Q_{66}	45	U_3
01	n_1	16	A_{26}	31	V^*_{1A}	46	$-n/2$
02	θ_2	17	B_{11}	32	V^*_{2A}	47	V^*_{3D}
03	n_2	18	B_{22}	33	V^*_{3A}	48	V^*_{4D}
04	θ_3	19	B_{12}	34	V^*_{4A}	49	$2\theta_i$
05	n_3	20	B_{66}	35	V^*_{1B}	50	$4\theta_i$
06	θ_4	21	B_{16}	36	V^*_{2B}	51	$N_1^{N^*}$
07	ΔT	22	B_{26}	37	V^*_{3B}	52	$N_2^{N^*}$
08	c	23	D_{11}	38	V^*_{4B}	53	$N_6^{N^*}$
09	U_4	24	D_{22}	39	V^*_{1D}	54	$M_1^{N^*}$
10	U_1	25	D_{12}	40	V^*_{2D}	55	$M_2^{N^*}$
11	A_{11}	26	D_{66}	41	h_o	56	$M_6^{N^*}$
12	A_{22}	27	D_{16}	42	$\frac{1}{2}(U_1+U_4)$	57	e_x
13	A_{12}	28	D_{26}	43	$U_5=\frac{1}{2}(U_1-U_4)$	58	e_y
14	A_{66}	29	Q_{12}	44	U_2	59	h

A^*_{ij}

```
000  76 LBL
001  11  A
002  01  1
003  02  2
004  66 PAU
005  43 RCL
006  17  17
007  42 STO
008  59  59
009  43 RCL
010  42  42
011  75  -
012  43 RCL
013  43  43
014  95  =
015  42 STO
016  09  09
017  85  +
018  02  2
019  65  ×
020  43 RCL
021  43  43
022  95  =
023  42 STO
024  10  10
025  85  +
026  43 RCL
027  44  44
028  65  ×
029  43 RCL
030  31  31
031  85  +
032  43 RCL
033  32  32
034  65  ×
035  43 RCL
036  45  45
037  95  =
038  42 STO
039  11  11
040  75  -
041  02  2
042  65  ×
043  43 RCL
044  44  44
045  65  ×
046  43 RCL
047  31  31
048  95  =
049  42 STO
050  12  12
051  43 RCL
052  09  09
053  75  -
054  43 RCL
055  45  45
056  65  ×
057  43 RCL
058  32  32
059  95  =
060  42 STO
061  13  13
062  75  -
063  43 RCL
064  42  42
065  85  +
066  02  2
067  65  ×
068  43 RCL
069  43  43
070  95  =
071  42 STO
072  14  14
073  43 RCL
074  33  33
075  65  ×
076  43 RCL
077  44  44
078  55  -
079  02  2
080  85  +
081  43 RCL
082  34  34
083  65  ×
084  43 RCL
085  45  45
086  95  =
087  42 STO
088  15  15
089  75  -
090  02  2
091  65  ×
092  43 RCL
093  45  45
094  65  ×
095  43 RCL
096  34  34
097  95  =
098  42 STO
099  16  16
```

B^*_{ij}

```
100  43 RCL
101  44  44
102  65  ×
103  43 RCL
104  35  35
105  85  +
106  43 RCL
107  45  45
108  65  ×
109  43 RCL
110  36  36
111  95  =
112  42 STO
113  17  17
114  75  -
115  02  2
116  65  ×
117  43 RCL
118  44  44
119  65  ×
120  43 RCL
121  35  35
122  95  =
123  42 STO
124  18  18
125  43 RCL
126  45  45
127  65  ×
128  43 RCL
129  36  36
130  95  =
131  94 +/-
132  42 STO
133  19  19
134  42 STO
135  20  20
136  43 RCL
137  44  44
138  65  ×
139  43 RCL
140  37  37
141  55  ÷
142  02  2
143  85  +
144  43 RCL
145  45  45
146  65  ×
147  43 RCL
148  38  38
149  95  =
150  42 STO
151  21  21
152  75  -
153  02  2
154  65  ×
155  43 RCL
156  45  45
157  65  ×
158  43 RCL
159  38  38
160  95  =
161  42 STO
162  22  22
```

D^*_{ij}

```
163  43 RCL
164  10  10
165  85  +
166  43 RCL
167  44  44
168  65  ×
169  43 RCL
170  39  39
171  85  +
172  43 RCL
173  45  45
174  65  ×
175  43 RCL
176  40  40
177  95  =
178  42 STO
179  23  23
180  75  -
181  02  2
182  65  ×
183  43 RCL
184  44  44
185  65  ×
186  43 RCL
187  39  39
188  95  =
189  42 STO
190  24  24
191  43 RCL
192  09  09
193  75  -
194  43 RCL
195  45  45
196  65  ×
197  43 RCL
198  40  40
199  95  =
200  42 STO
201  25  25
202  75  -
203  43 RCL
204  42  42
205  85  +
206  02  2
207  65  ×
208  43 RCL
209  43  43
210  95  =
211  42 STO
212  26  26
213  43 RCL
214  44  44
215  65  ×
216  43 RCL
217  47  47
218  55  ÷
219  02  2
220  85  +
221  43 RCL
222  45  45
223  65  ×
224  43 RCL
225  48  48
226  95  =
227  42 STO
228  27  27
229  75  -
230  02  2
231  65  ×
232  43 RCL
233  45  45
234  65  ×
235  43 RCL
236  48  48
237  95  =
238  42 STO
239  28  28
```

A_{ij}

```
240  91 R/S
241  76 LBL
242  12  B
243  43 RCL
244  59  59
245  49 PRD
246  11  11
247  49 PRD
248  12  12
249  49 PRD
250  13  13
251  49 PRD
252  14  14
253  49 PRD
254  15  15
255  49 PRD
256  16  16
```

B_{ij}

```
257  55  ÷
258  02  2
259  95  =
260  49 PRD
261  17  17
262  49 PRD
263  18  18
264  49 PRD
265  19  19
266  49 PRD
267  20  20
268  49 PRD
269  21  21
270  49 PRD
271  22  22
```

D_{ij}

```
272  55  ÷
273  43 RCL
274  59  59
275  55  ÷
276  06  6
277  95  =
278  49 PRD
279  23  23
280  49 PRD
281  24  24
282  49 PRD
283  25  25
284  49 PRD
285  26  26
286  49 PRD
287  27  27
288  49 PRD
289  28  28
290  00  0
291  00  0
292  00  0
293  32 INV
294  90 LST
295  91 R/S
296  00  0
297  00  0
298  00  0
299  00  0
300  00  0
301  00  0
302  00  0
303  00  0
304  00  0
305  00  0
306  00  0
307  00  0
308  00  0
309  00  0
310  00  0
311  00  0
312  00  0
313  00  0
314  00  0
315  00  0
316  00  0
317  00  0
318  00  0
319  00  0
```

	0.	00	00
	0.		01
	-45.		02
	0.		03
	0.	00	04
	0.	00	05
	-45.	00	06
	-150.	00	07
	5.	-03	08
	22.607356	09	09
	76.368218	09	10
	113.31557	06	11
	113.31557	06	12
A_{ij}	84.635573	06	13
	93.181724	06	14
	0.	00	15
	0.	00	16
	0.	00	17
	0.	00	18
	0.	00	19
B_{ij}	0.	00	20
	-42.866245	03	21
	-42.866245	03	22
	37.771858	00	23
	37.771858	00	24
D_{ij}	28.211858	00	25
	31.060575	00	26
	0.	00	27
	0.	00	28
	2.8969244	09	29
	7.17	09	30
	0.	00	31
	-1.	00	32
	0.	00	33
	0.	00	34
	0.	00	35
	0.	00	36
	-500.	-03	37
	0.	00	38
	0.	00	39
	-1.	00	40
	125.	-06	41
	49.487787	09	42
	26.880431	09	43
	85.73249	09	44
	19.710431	09	45
	-8.	00	46
	0.	00	47
	0.	00	48
	-90.	00	49
	-180.	00	50
	7.3107032	06	51
	7.3107032	06	52
	0.	00	53
	0.	00	54
	0.	00	55
	2.16219	06	56
	-1.5	-06	57
	1.125	-03	58
	2.	-03	59

	0.	00	00
	0.		01
	90.		02
	0.		03
	0.	00	04
	0.	00	05
	90.	00	06
	-150.	00	07
	5.	-03	08
	22.607356	09	09
	76.368218	09	10
	192.1573	06	11
	192.1573	06	12
	5.7938489	06	13
	14.34	06	14
	0.	00	15
	0.	00	16
	-85.73249	03	17
	85.73249	03	18
	0.	00	19
	0.	00	20
	0.	00	21
	0.	00	22
	64.052433	00	23
	64.052433	00	24
	1.931283	00	25
	4.78	00	26
	0.	00	27
	0.	00	28
	2.8969244	09	29
	7.17	09	30
	0.	00	31
	1.	00	32
	0.	00	33
	0.	00	34
	-500.	-03	35
	0.	00	36
	0.	00	37
	0.	00	38
	0.	00	39
	1.	00	40
	125.	-06	41
	49.487787	09	42
	26.880431	09	43
	85.73249	09	44
	19.710431	09	45
	-8.	00	46
	0.	00	47
	0.	00	48
	180.	00	49
	360.	00	50
	7.3107032	06	51
	7.3107032	06	52
	0.	00	53
	2.16219	06	54
	-2.16219	06	55
	0.	00	56
	-1.5	-06	57
	1.125	-03	58
	2.	-03	59

TAPE #10: COMPLIANCE OF GENERAL LAMINATES
(Use Side #1 only)

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
0	Results from Tape #9 (Step 2) must be in storage.			
1	Calculate α_{ij}, β_{ij}, δ_{ij}*		A	1
2	Calculate N_i^N, M_i^N		B	51

* Time required for calculation is 230" or 3'50".

TAPE #10A: INVERSION CHECK

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Check Inversion**		A	7
2	Data Rearrangement		D	51

** Time required is 110" or 1'50".

Tape# 10 Title COMPLIANCE OF GENERAL LAMINATES

A'	B'	C'	D'	E'
A $\alpha_{ij}, \beta_{ij}, \delta_{ij}$	B N_i^N, M_i^N	C	D	E

00	15 α_{16}	30 δ_{16}	45
01	16 α_{26}	31 δ_{26}	46
02	17 β_{11}	32	47
03	18 β_{22}	33	48
04	19 β_{12}	34	49
05	20 β_{21}	35	50
06	21 β_{66}	36	51 N_1^N
07	22 β_{16}	37	52 N_2^N
08	23 β_{61}	38	53 N_6^N
09	24 β_{26}	39	54 M_1^N
10	25 β_{62}	40	55 M_2^N
11 α_{11}	26 δ_{11}	41	56 M_6^N
12 α_{22}	27 δ_{22}	42	57 e_x
13 α_{12}	28 δ_{12}	43	58 e_y
14 α_{66}	29 δ_{21}	44	59 h

Data Rearrang

000	76	LBL	
001	11	A	
002	02	2	
003	03	3	
004	00	0	
005	66	PAU	
006	43	RCL	
007	11	11	
008	42	STO	
009	08	08	
010	43	RCL	
011	13	13	
012	42	STO	
013	09	09	
014	43	RCL	
015	15	15	
016	42	STO	
017	10	10	
018	43	RCL	
019	23	23	
020	42	STO	
021	29	29	
022	43	RCL	
023	24	24	
024	42	STO	
025	35	35	
026	43	RCL	
027	25	25	
028	42	STO	
029	30	30	
030	43	RCL	
031	35	35	
032	43	RCL	
033	25	25	
034	42	STO	
035	41	41	
036	43	RCL	
037	23	23	
038	42	STO	
039	42	42	
040	43	RCL	
041	11	11	
042	42	STO	
043	43	43	
044	43	RCL	
045	21	21	
046	42	STO	
047	13	13	
048	43	STO	
049	23	23	
050	42	STO	
051	28	28	
052	42	STO	
053	38	38	
054	43	RCL	
055	12	12	
056	42	STO	
057	15	15	
058	43	RCL	
059	19	19	
060	42	STO	
061	17	17	
062	42	STO	
063	27	27	
064	42	STO	
065	33	33	
066	42	STO	
067	12	12	
068	43	RCL	
069	20	20	
070	42	STO	
071	14	14	
072	00	0	
073	49	PRD	
074	00	00	
075	49	PRD	
076	01	01	
077	49	PRD	
078	02	02	
079	49	PRD	
080	03	03	
081	49	PRD	
082	04	04	
083	49	PRD	
084	05	05	
085	49	PRD	
086	06	06	
087	49	PRD	
088	07	07	
089	49	PRD	
090	44	44	
091	49	PRD	
092	45	45	
093	49	PRD	
094	46	46	
095	49	PRD	
096	47	47	
097	49	PRD	
098	48	48	
099	49	PRD	
100	49	49	
101	49	PRD	
102	50	50	
103	98	ADV	
104	06	6	
105	36	PGM	
106	02	02	
107	11	A	
108	01	1	
109	36	PGM	
110	02	02	
111	12	B	
112	36	PGM	
113	02	02	
114	13	C	
115	25	CLP	
116	36	PGM	
117	02	02	

Inversion

N_A^N, M_A^N

160	17	B'	
161	91	R/S	
162	76	LBL	
163	12	B	
164	43	RCL	
165	59	59	
166	49	PRD	
167	51	51	
168	49	PRD	
169	52	52	
170	49	PRD	
171	53	53	
172	43	RCL	
173	59	59	
174	33	X²	
175	55	÷	
176	02	2	
177	95	=	
178	49	PRD	
179	54	54	
180	49	PRD	
181	55	55	
182	49	PRD	
183	56	56	
184	05	5	
185	01	1	
186	32	INV	
187	90	LST	
188	98	ADV	
189	91	R/S	
190	00	0	
191	00	0	
192	00	0	
193	00	0	
194	00	0	
195	00	0	
196	00	0	
197	00	0	
198	00	0	
199	00	0	
200	00	0	
201	00	0	
202	00	0	
203	00	0	
204	00	0	
205	00	0	
206	00	0	
207	00	0	
208	00	0	
209	00	0	
210	00	0	
211	00	0	
212	00	0	
213	00	0	
214	00	0	
215	00	0	
216	00	0	
217	00	0	
218	00	0	
219	00	0	
220	00	0	
221	00	0	
222	00	0	
223	00	0	
224	00	0	
225	00	0	
226	00	0	
227	00	0	
228	00	0	
229	00	0	
230	00	0	
231	00	0	
232	00	0	
233	00	0	
234	00	0	
235	00	0	
236	00	0	
237	00	0	
238	00	0	
239	00	0	

Tape # 10 A Compliance General Laminates

```
000  76 LBL
001  11  A
002  01  1
003  42 STO
004  00  00
005  01  1
006  01  1
007  00  0
008  66 PAU
009  43 RCL
010  00  00
011  32 X:T
012  12  B
013  69 DP
014  20  20
015  07  7
016  32 X:T
017  43 RCL
018  00  00
019  67  EQ
020  58 FIX
021  04  04
022  00  0
023  09  9
024  76 LBL
025  58 FIX
026  91 R/S
027  76 LBL
028  12  B
029  43 RCL
030  44  44
031  67  EQ
032  30  X²
033  42 STO
034  45  45
035  67  EQ
036  34 FX
037  43 RCL
038  46  46
039  67  EQ
040  35 1/X
041  42 STO
042  47  47
043  67  EQ
044  23 LNX
045  43 RCL
046  48  48
047  67  EQ
048  28 LOG
049  43 RCL
050  49  49
051  67  EQ
052  24 CE
053  12  B
054  76 LBL
055  30  X²
056  43 RCL
057  44  44
058  48 EXC
059  49  49
060  48 EXC
061  44  44
062  08  8
063  42 STO
064  01  01
065  03  3
066  08  8
067  42 STO
068  02  02
069  15  E
070  76 LBL
071  13  C
072  01  1
073  32 X:T
074  43 RCL
075  49  49
076  67  EQ
077  16 A'
078  60 DEG
079  76 LBL
080  60 DEG
081  02  2
082  32 X:T
083  43 RCL
084  49  49
085  67  EQ
086  17 B'
087  70 RAD
088  76 LBL
089  70 RAD
090  03  3
091  32 X:T
092  43 RCL
093  49  49
094  67  EQ
095  10 E'
096  80 GRD
097  76 LBL
098  80 GRD
099  04  4
100  32 X:T
101  43 RCL
102  49  49
103  67  EQ
104  19 D'
105  50 I×I
106  76 LBL
107  50 I×I
108  05  5
109  32 X:T
110  43 RCL
111  49  49
112  67  EQ
113  38 SIN
114  45 Y^X
115  76 LBL
116  45 Y^X
117  06  6
118  32 X:T
119  43 RCL
120  49  49
121  67  EQ
122  39 COS
123  13  C
124  76 LBL
125  16 A'
126  01  1
127  42 STO
128  06  06
129  43 RCL
130  49  49
131  48 EXC
132  44  44
133  48 EXC
134  49  49
135  03  3
136  08  8
137  42 STO
138  04  04
139  08  8
140  42 STO
141  05  05
142  18 C'
143  76 LBL
144  18 C'
145  07  7
146  32 X:T
147  43 RCL
148  06  06
149  67  EQ
150  00  00
151  13  13
152  73 RC*
153  04  04
154  63 EX*
155  05  05
156  63 EX*
157  04  04
158  69 DP
159  24  24
160  69 DP
161  25  25
162  69 DP
163  26  26
164  61 GTO
165  01  01
166  47  47
167  76 LBL
168  34 FX
169  01  1
170  04  4
171  42 STO
172  01  01
173  03  3
174  08  8
175  42 STO
176  02  02
177  43 RCL
178  45  45
179  48 EXC
180  49  49
181  48 EXC
182  45  45
183  15  E
184  76 LBL
185  35 1/X
186  43 RCL
187  46  46
188  48 EXC
189  49  49
190  48 EXC
191  46  46
192  02  2
193  00  0
194  42 STO
195  01  01
196  03  3
197  08  8
198  42 STO
199  02  02
200  15  E
201  76 LBL
202  23 LNX
203  43 RCL
204  47  47
205  48 EXC
206  49  49
207  48 EXC
208  47  47
209  02  2
210  06  6
211  42 STO
212  01  01
213  03  3
214  08  8
215  42 STO
216  02  02
217  15  E
218  76 LBL
219  28 LOG
220  43 RCL
221  48  48
222  48 EXC
223  49  49
224  48 EXC
225  48  48
226  03  3
227  02  2
228  42 STO
229  01  01
230  03  3
231  08  8
232  42 STO
233  02  02
234  15  E
235  76 LBL
236  24 CE
237  03  3
238  08  8
239  42 STO
```

```
240   01   01
241   03   3
242   08   8
243   42 STO
244   02   02
245   15   E
246   76 LBL
247   17 B'
248   01   1
249   42 STO
250   06   06
251   43 RCL
252   49   49
253   48 EXC
254   45   45
255   48 EXC
256   49   49
257   03   3
258   08   8
259   42 STO
260   04   04
261   01   1
262   04   4
263   42 STO
264   05   05
265   18 C'
266   76 LBL
267   10 E'
268   01   1
269   42 STO
270   06   06
271   43 RCL
272   49   49
273   48 EXC
274   46   46
275   48 EXC
276   49   49
277   03   3
278   08   8
279   42 STO
280   04   04
281   02   2
282   00   0
283   42 STO
284   05   05
285   18 C'
286   76 LBL
287   19 D'
288   01   1
289   42 STO
290   06   06
291   43 RCL
292   49   49
293   48 EXC
294   47   47
295   48 EXC
296   49   49
297   03   3
298   08   8
299   42 STO
300   04   04
301   02   2
302   06   6
303   42 STO
304   05   05
305   18 C'
306   76 LBL
307   38 SIN
308   01   1
309   42 STO
310   06   06
311   43 RCL
312   49   49
313   48 EXC
314   48   48
315   48 EXC
316   49   49
317   03   3
318   08   8
319   42 STO
```

```
320   04   04
321   03   3
322   02   2
323   42 STO
324   05   05
325   18 C'
326   76 LBL
327   36 COS
328   01   1
329   42 STO
330   06   06
331   03   3
332   08   8
333   42 STO
334   04   04
335   03   3
336   08   8
337   42 STO
338   05   05
339   18 C'
340   76 LBL
341   15   E
342   01   1
343   42 STO
344   07   07
345   07   7
346   32 X:T
347   43 RCL
348   07   07
349   67   EQ
350   13   C
351   75 RC+
352   01   01
353   63 EX+
354   02   02
355   63 EX+
356   01   01
357   69 DP
358   21   21
359   69 DP
360   22   22
361   69 DP
362   27   27
363   61 GTO
364   08   08
365   47   47
366   76 LBL
367   14   D
368   05   5
369   66 PAU
370   43 RCL
371   08   08
372   42 STO
373   11   11
374   99 PRT
375   43 RCL
376   15   15
377   42 STO
378   12   12
379   99 PRT
380   43 RCL
381   09   09
382   42 STO
383   13   13
384   99 PRT
385   43 RCL
386   22   22
387   42 STO
388   14   14
389   99 PRT
390   43 RCL
391   10   10
392   42 STO
393   15   15
394   99 PRT
395   43 RCL
396   16   16
397   99 PRT
398   98 ADV
399   43 RCL
```

Data Rearrang.

```
400   42 STO
402   17   17
403   99 PRT
404   43 RCL
405   18   18
406   99 PRT
407   43 RCL
408   32   32
409   42 STO
410   19   19
411   99 PRT
412   43 RCL
413   27   27
414   42 STO
415   20   20
416   99 PRT
417   43 RCL
418   25   25
419   42 STO
420   21   21
421   99 PRT
422   43 RCL
423   38   38
424   42 STO
425   22   22
426   99 PRT
427   43 RCL
428   28   28
429   42 STO
430   23   23
431   99 PRT
432   43 RCL
433   39   39
434   42 STO
435   24   24
436   99 PRT
437   43 RCL
438   34   34
439   42 STO
440   25   25
441   99 PRT
442   98 ADV
443   43 RCL
444   29   29
445   42 STO
446   26   26
447   99 PRT
448   43 RCL
449   36   36
450   42 STO
451   27   27
452   99 PRT
453   43 RCL
454   30   30
455   42 STO
456   28   28
457   99 PRT
458   43 RCL
459   43   43
460   42 STO
461   29   29
462   99 PRT
463   43 RCL
464   31   31
465   42 STO
466   30   30
467   99 PRT
468   43 RCL
469   37   37
470   42 STO
471   31   31
472   99 PRT
473   98 ADV
474   05   5
475   01   1
476   22 INV
477   90 LST
478   98 ADV
479   91 R/S
```

	6. 00	14.621406 03	51	N_i^N	6. 00	14.621406 03	51
		14.621406 03	52			14.621406 03	52
		0. 00	53			0. 00	53
		0. 00	54	M_i^N		4.3243799 00	54
	1.677421 27	0. 00	55		1.677421 27	-4.3243799 00	55
		4.3243799 00	56			0. 00	56
		-1.5-06	57			-1.5-06	57
		1.125-03	58			1.125-03	58
23.712556-09	α_{11}	2.-03	59	12.948013-09		2.-03	59
23.712556-09	α_{22}			12.948013-09			
-11.154947-09	α_{12}			-390.40323-12			
26.676832-09	α_{66}			69.735007-09			
0. 00	α_{16}	0. 00	00	0. 00		0. 00	00
0. 00	α_{26}	43. 00	01	0. 00		43. 00	01
		43. 00	02			43. 00	02
		49. 00	03			49. 00	03
0. 00	β_{11}	6. 00	04	17.330573-06		6. 00	04
0. 00	β_{22}	7. 00	05	-17.330573-06		7. 00	05
0. 00	β_{12}	1.677421 27	06	-82.744711-18		1.677421 27	06
0. 00	β_{21}	6. 00	07	84.9-18		6. 00	07
0. 00	β_{66}	23.712556-09	08	0. 00		12.948013-09	08
17.330573-06	β_{16}	-11.154947-09	09	0. 00		-390.40323-12	09
17.330573-06	β_{61}	0. 00	10	0. 00		0. 00	10
17.330573-06	β_{26}	23.712556-09	11	0. 00		12.948013-09	11
17.330573-06	β_{62}	23.712556-09	12	0. 00		12.948013-09	12
		-11.154947-09	13			-390.40323-12	13
71.137669-03	δ_{11}	26.676832-09	14	38.844038-03		69.735007-09	14
71.137669-03	δ_{22}	0. 00	15	38.844038-03		0. 00	15
-33.464841-03	δ_{12}	0. 00	16	-1.1712097-03		0. 00	16
80.030496-03	δ_{66}	0. 00	17	209.20502-03		17.330573-06	17
0. 00	δ_{16}	0. 00	18	0. 00		-17.330573-06	18
0. 00	δ_{26}	0. 00	19	0. 00		-82.744711-18	19
		0. 00	20			84.9-18	20
		0. 00	21			0. 00	21
		17.330573-06	22			0. 00	22
		17.330573-06	23			0. 00	23
		17.330573-06	24			0. 00	24
		17.330573-06	25			0. 00	25
		71.137669-03	26			38.844038-03	26
		71.137669-03	27			38.844038-03	27
		-33.464841-03	28			-1.1712097-03	28
		80.030496-03	29			209.20502-03	29
		0. 00	30			0. 00	30
		0. 00	31			0. 00	31
		0. 00	32			-82.744711-18	32
		0. 00	33			-17.330573-06	33
		17.330573-06	34			0. 00	34
		-33.464841-03	35			-1.1712097-03	35
		71.137669-03	36			38.844038-03	36
		0. 00	37			0. 00	37
		17.330573-06	38			0. 00	38
		17.330573-06	39			0. 00	39
		0. 00	40			0. 00	40
		0. 00	41			0. 00	41
		0. 00	42			0. 00	42
		80.030496-03	43			209.20502-03	43
		1. 00	44			1. 00	44
		2. 00	45			2. 00	45
		3. 00	46			3. 00	46
		4. 00	47			4. 00	47
		5. 00	48			5. 00	48
		6. 00	49			6. 00	49
		0. 00	50			0. 00	50
		14.621406 03	51			14.621406 03	51
		14.621406 03	52			14.621406 03	52
		0. 00	53			0. 00	53
		0. 00	54			4.3243799 00	54
		0. 00	55			-4.3243799 00	55
		4.3243799 00	56			0. 00	56
		-1.5-06	57			-1.5-06	57
		1.125-03	58			1.125-03	58
		2.-03	59			2.-03	59

TAPE #11: IN-PLANE STRAINS AND CURVATURE OF GENERAL LAMINATES

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
0	Results of Tape #10A are in storage.			
1	Calculate ϵ_i^{oN}, k_i^N		A	k_6^N
2	Calculate ϵ_i^N	z	D	ϵ_6^N
3	Calculate $\epsilon_i^{o(N+M)}$, k_i^{N+M}	N_1^M	B	N_1^M
		N_2^M	R/S	N_2^M
		N_6^M	R/S	N_6^M
		M_1^M	R/S	M_1^M
		M_2^M	R/S	M_2^M
		M_6^M	R/S	k_6^M
4	Calculate ϵ_i^M	z	D	ϵ_6^M

Tape# 11 Title IN-PLANE STRAIN AND CURVATURE OF GENERAL LAMINATES

A'	B'	C'	D'	E'
A ϵ_i^{oN}, k_i^N	B ϵ_i^{oM}, k_i^{oM}	C	D ϵ_i^N, ϵ_i^M	E

00	15 α_{16}	30 δ_{16}	45 $\Sigma\epsilon_1$
01 ϵ_1^{oN}	16 α_{26}	31 δ_{26}	46 $\Sigma\epsilon_2$
02 ϵ_2^{oN}	17 β_{11}	32	47 $\Sigma\epsilon_6$
03 ϵ_6^{oN}	18 β_{22}	33	48 Σk_1
04 k_1^N	19 β_{12}	34	49 Σk_2
05 k_2^N	20 β_{21}	35	50 Σk_6
06 k_6^N	21 β_{66}	36 ϵ_1^{oM}	51 N_1^N, N_1^M
07 ϵ_1	22 β_{16}	37 ϵ_2^{oM}	52 N_2^N, N_2^M
08 ϵ_2	23 β_{61}	38 ϵ_6^{oM}	53 N_6^N, N_6^M
09 ϵ_6	24 β_{26}	39 k_1^M	54 M_1^N, M_1^M
10	25 β_{62}	40 k_2^M	55 M_2^N, M_2^M
11 α_{11}	26 δ_{11}	41 k_6^M	56 M_6^N, M_6^M
12 α_{22}	27 δ_{22}	42	57 ϵ_x
13 α_{12}	28 δ_{12}	43	58 ϵ_y
14 α_{66}	29 δ_{66}	44	59 h, z

TAPE # 11 IN-PLANE STRAINS AND CURVATURE GENERAL LAMINATES

ϵ_x^{ON}

000	76	LBL
001	11	A
002	71	SBR
003	03	X³
004	43	RCL
005	45	45
006	42	STO
007	01	01
008	43	RCL
009	46	46
010	42	STO
011	02	02
012	43	RCL
013	47	47
014	42	STO
015	03	03
016	43	RCL
017	48	48
018	42	STO
019	04	04
020	43	RCL
021	49	49
022	42	STO
023	05	05
024	43	RCL
025	50	50
026	42	STO
027	06	06
028	91	R/S

ϵ_x^{OM}

029	76	LBL
030	12	B
031	42	STO
032	51	51
033	99	PRT
034	91	R/S
035	42	STO
036	52	52
037	99	PRT
038	91	R/S
039	42	STO
040	53	53
041	99	PRT
042	91	R/S
043	42	STO
044	54	54
045	99	PRT
046	91	R/S
047	42	STO
048	55	55
049	99	PRT
050	91	R/S
051	42	STO
052	56	56
053	99	PRT
054	71	SBR
055	33	X²
056	43	RCL
057	45	45
058	42	STO
059	36	36
060	43	RCL
061	46	46
062	42	STO
063	37	37
064	43	RCL
065	47	47
066	42	STO
067	38	38
068	43	RCL
069	48	48
070	42	STO
071	39	39
072	43	RCL
073	49	49
074	42	STO
075	40	40
076	43	RCL
077	50	50
078	42	STO
079	41	41
080	91	R/S
081	76	LBL
082	32	X↑
083	01	1
084	01	1
085	66	PAU
086	43	RCL
087	11	11
088	65	×
089	43	RCL
090	51	51
091	85	+
092	43	RCL
093	10	10
094	65	×
095	43	RCL
096	52	52
097	85	+
098	43	RCL
099	15	15
100	65	×
101	43	RCL
102	53	53
103	85	+
104	43	RCL
105	17	17
106	65	×
107	43	RCL
108	54	54
109	85	+
110	43	RCL
111	19	19
112	65	×
113	43	RCL
114	55	55
115	85	+
116	43	RCL
117	22	22
118	65	×
119	43	RCL
120	56	56
121	95	=
122	42	STO
123	45	45
124	43	RCL
125	13	13
126	65	×
127	43	RCL
128	51	51
129	85	+
130	43	RCL
131	12	12
132	65	×
133	43	RCL
134	52	52
135	85	+
136	43	RCL
137	16	16
138	65	×
139	43	RCL
140	53	53
141	85	+
142	43	RCL
143	20	20
144	65	×
145	43	RCL
146	54	54
147	85	+
148	43	RCL
149	18	18
150	65	×
151	43	RCL
152	55	55
153	85	+
154	43	RCL
155	24	24
156	65	×
157	43	RCL
158	56	56
159	95	=
160	42	STO
161	46	46
162	43	RCL
163	15	15
164	65	×
165	43	RCL
166	51	51
167	85	+
168	43	RCL
169	16	16
170	65	×
171	43	RCL
172	52	52
173	85	+
174	43	RCL
175	14	14
176	65	×
177	43	RCL
178	53	53
179	85	+
180	43	RCL
181	23	23
182	65	×
183	43	RCL
184	54	54
185	85	+
186	43	RCL
187	25	25
188	65	×
189	43	RCL
190	55	55
191	85	+
192	43	RCL
193	21	21
194	65	×
195	43	RCL
196	56	56
197	95	=
198	42	STO
199	47	47
200	43	RCL
201	17	17
202	65	×
203	43	RCL
204	51	51
205	85	+
206	43	RCL
207	20	20
208	65	×
209	43	RCL
210	52	52
211	85	+
212	43	RCL
213	23	23
214	65	×
215	43	RCL
216	53	53
217	85	+
218	43	RCL
219	26	26
220	65	×
221	43	RCL
222	54	54
223	85	+
224	43	RCL
225	28	28
226	65	×
227	43	RCL
228	55	55
229	85	+
230	43	RCL
231	30	30
232	65	×
233	43	RCL
234	56	56
235	95	=
236	42	STO
237	48	48
238	43	RCL
239	19	19

```
240  65  ×
241  43 RCL
242  51  51
243  85  +
244  43 RCL
245  18  18
246  65  ×
247  43 RCL
248  52  52
249  85  +
250  43 RCL
251  25  25
252  65  ×
253  43 RCL
254  53  53
255  85  +
256  43 RCL
257  28  28
258  65  ×
259  43 RCL
260  54  54
261  85  +
262  43 RCL
263  27  27
264  65  ×
265  43 RCL
266  55  55
267  85  +
268  43 RCL
269  31  31
270  65  ×
271  43 RCL
272  56  56
273  95  =
274  42 STO
275  49  49
276  43 RCL
277  33  33
278  65  ×
279  43 RCL
280  51  51
281  85  +
282  43 RCL
283  24  24
284  65  ×
285  43 RCL
286  52  52
287  85  +
288  43 RCL
289  21  21
290  65  ×
291  43 RCL
292  53  53
293  85  +
294  43 RCL
295  30  30
296  65  ×
297  43 RCL
298  54  54
299  85  +
300  43 RCL
301  31  31
302  65  ×
303  43 RCL
304  55  55
305  85  +
306  43 RCL
307  29  29
308  65  ×
309  43 RCL
310  56  56
311  95  =
312  42 STO
313  50  50
314  92 RTN
315  91 R/S
316  76 LBL
317  14  D
318  42 STO
319  59  59
```

```
320  65  ×
321  43 RCL
322  46  46
323  85  +
324  43 RCL
325  45  45
326  95  =
327  99 PRT
328  42 STO
329  07  07
330  43 RCL
331  46  46
332  85  +
333  43 RCL
334  59  59
335  65  ×
336  43 RCL
337  49  49
338  95  =
339  99 PRT
340  42 STO
341  08  08
342  43 RCL
343  47  47
344  85  +
345  43 RCL
346  59  59
347  65  ×
348  43 RCL
349  50  50
350  95  =
351  42 STO
352  09  09
353  99 PRT
354  98 ADV
355  91 R/S
356  00  0
357  00  0
358  00  0
359  00  0
360  00  0
361  00  0
362  00  0
363  00  0
364  00  0
365  00  0
366  00  0
367  00  0
368  00  0
369  00  0
370  00  0
371  00  0
372  00  0
373  00  0
374  00  0
375  00  0
376  00  0
377  00  0
378  00  0
379  00  0
380  00  0
381  00  0
382  00  0
383  00  0
384  00  0
385  00  0
386  00  0
387  00  0
388  00  0
389  00  0
390  00  0
391  00  0
392  00  0
393  00  0
394  00  0
395  00  0
396  00  0
397  00  0
398  00  0
399  00  0
```

ϵ_2

TAPE #11 IN-PLANE STRAINS AND CURVATURE/SAMPLE PROBLEMS

258.5539-06	ϵ_i^N	684.99239-06
258.5539-06		-167.88459-06
852.87698-06		0. 00
1. 00	N_i^M	1. 00
0. 00		0. 00
0. 00		0. 00
0. 00	M_i^M	0. 00
0. 00		0. 00
0. 00		0. 00
23.712556-09	ϵ_i^M	30.278586-09
-11.154947-09		-390.40323-12
17.330573-09		0. 00

0. 00	00	0. 00	00
258.5539-06	01	258.5539-06	01
258.5539-06	02	258.5539-06	02
0. 00	03	0. 00	03
0. 00	04	426.43849-03	04
0. 00	05	-426.43849-03	05
852.87698-03	06	0. 00	06
23.712556-09	07	30.278586-09	07
-11.154947-09	08	-390.40323-12	08
17.330573-09	09	0. 00	09
0. 00	10	0. 00	10
23.712556-09	11	12.948013-09	11
23.712556-09	12	12.948013-09	12
-11.154947-09	13	-390.40323-12	13
26.676832-09	14	69.735007-09	14
0. 00	15	0. 00	15
0. 00	16	0. 00	16
0. 00	17	17.330573-06	17
0. 00	18	-17.330573-06	18
0. 00	19	-82.744711-18	19
0. 00	20	84.9-18	20
0. 00	21	0. 00	21
17.330573-06	22	0. 00	22
17.330573-06	23	0. 00	23
17.330573-06	24	0. 00	24
17.330573-06	25	0. 00	25
71.137669-03	26	38.844038-03	26
71.137669-03	27	38.844038-03	27
-33.464841-03	28	-1.1712097-03	28
80.030496-03	29	209.20502-03	29
0. 00	30	0. 00	30
0. 00	31	0. 00	31
0. 00	32	-82.744711-18	32
0. 00	33	-17.330573-06	33
17.330573-06	34	0. 00	34
-33.464841-03	35	-1.1712097-03	35
23.712556-09	36	12.948013-09	36
-11.154947-09	37	-390.40323-12	37
0. 00	38	0. 00	38
0. 00	39	17.330573-06	39
0. 00	40	-82.744711-18	40
17.330573-06	41	0. 00	41
0. 00	42	0. 00	42
80.030496-03	43	209.20502-03	43
1. 00	44	1. 00	44
23.712556-09	45	12.948013-09	45
-11.154947-09	46	-390.40323-12	46
0. 00	47	0. 00	47
0. 00	48	17.330573-06	48
0. 00	49	-82.744711-18	49
17.330573-06	50	0. 00	50
1. 00	51	1. 00	51
0. 00	52	0. 00	52
0. 00	53	0. 00	53
0. 00	54	0. 00	54
0. 00	55	0. 00	55
0. 00	56	0. 00	56
-1.5-06	57	-1.5-06	57
1.125-03	58	1.125-03	58
1. -03	59	1. -03	59

TAPE #12: STRENGTH RATIOS OF GENERAL LAMINATES

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
0	Results of Tape #11 must be in storage			
1	Data rearrangement		A	e_y
2	Calculate strains ϵ_j^N , e_j^M enter distance from middle plane	z	B	ϵ_6^M
3	Enter strength parameter in strain space. Use only Side #3 of ply data card; Side #4 must not be entered.		3	3
4	Calculate strength ratio	$\theta_i(z)$	E	R

Tape# 12 Title STRENGTH RATIOS OF GENERAL LAMINATES

A'	B'	C'	D'	E'
A	B e_j^N , e_j^M	C	D	E R

00 θ_i	15 e_6^{oM}	30	45
01 e_1^{oN}	16 k_1^M	31	46
02 e_2^{oN}	17 k_2^M	32 $e_1^M(\theta_i)$	47
03 e_6^{oN}	18 k_6^M	33 $e_2^M(\theta_i)$	48
04 k_1^N	19 e_x	34 $e_6^M(\theta_i)$	49
05 k_2^N	20 e_y	35	50
06 k_6^N	21 z	36	51
07 e_1^M	22 R	37	52
08 e_2^M	23 R'	38	53
09 e_6^M	24 $2\theta_i$	39	54 G_{xx}
10 e_1^N	25 $e_1^N(\theta_i)-e_x$	40	55 G_{yy}
11 e_2^N	26 $e_2^N(\theta_i)-e_y$	41	56 G_{xy}
12 e_6^N	27 $e_6^N(\theta_i)$	42	57 G_{ss}
13 e_1^{oM}	28	43	58 G_x
14 e_2^{oM}	29	44	59 G_y

```
000  76 LBL
001  11  A
002  43 RCL
003  36  36
004  42 STO
005  13  13
006  43 RCL
007  37  37
008  42 STO
009  14  14
010  43 RCL
011  38  38
012  42 STO
013  15  15
014  43 RCL
015  39  39
016  42 STO
017  16  16
018  43 RCL
019  40  40
020  42 STO
021  17  17
022  43 RCL
023  41  41
024  42 STO
025  18  18
026  43 RCL
027  59  59
028  42 STO
029  21  21
030  43 RCL
031  57  57
032  42 STO
033  19  19
034  43 RCL
035  58  58
036  42 STO
037  20  20
038  91 R/S
039  76 LBL
040  12  B
041  99 PRT
042  42 STO
043  21  21
044  65  ×
045  43 RCL
046  04  04
047  85  +
048  43 RCL
049  01  01
050  95  =
051  42 STO
052  10  10
053  43 RCL
054  21  21
055  65  ×
056  43 RCL
057  05  05
058  85  +
059  43 RCL
060  02  02
061  95  =
062  42 STO
063  11  11
064  43 RCL
065  21  21
066  65  ×
067  43 RCL
068  06  06
069  85  +
070  43 RCL
071  03  03
072  95  =
073  42 STO
074  12  12
075  43 RCL
076  21  21
077  65  ×
078  42 RCL
079  16  16
080  85  +
081  43 RCL
082  13  13
083  95  =
084  42 STO
085  07  07
086  43 RCL
087  21  21
088  65  ×
089  43 RCL
090  17  17
091  85  +
092  43 RCL
093  14  14
094  95  =
095  42 STO
096  08  08
097  43 RCL
098  21  21
099  65  ×
100  43 RCL
101  18  18
102  85  +
103  43 RCL
104  15  15
105  95  =
106  42 STO
107  09  09
108  43 RCL
109  10  10
110  99 PRT
111  43 RCL
112  11  11
113  99 PRT
114  43 RCL
115  12  12
116  99 PRT
117  98 ADV
118  43 RCL
119  07  07
120  99 PRT
121  43 RCL
122  08  08
123  99 PRT
124  43 RCL
125  09  09
126  99 PRT
127  98 ADV
128  91 R/S
129  76 LBL
130  15  E
131  42 STO
132  00  00
133  99 PRT
134  01  1
135  08  8
136  66 PAU
137  43 RCL
138  00  00
139  65  ×
140  02  2
141  95  =
142  42 STO
143  24  24
144  43 RCL
145  10  10
146  85  +
147  43 RCL
148  11  11
149  95  =
150  55  ÷
151  02  2
152  95  =
153  42 STO
154  28  28
155  75  -
156  43 RCL
157  11  11
158  95  =
159  42 STO
160  29  29
161  65  ×
162  43 RCL
163  24  24
164  39 COS
165  85  +
166  43 RCL
167  28  28
168  85  +
169  43 RCL
170  12  12
171  65  ×
172  43 RCL
173  24  24
174  38 SIN
175  55  ÷
176  02  2
177  75  -
178  43 RCL
179  19  19
180  95  =
181  42 STO
182  25  25
183  75  -
184  43 RCL
185  10  10
186  75  -
187  43 RCL
188  11  11
189  85  +
190  43 RCL
191  19  19
192  85  +
193  43 RCL
194  20  20
195  95  =
196  94 +/-
197  42 STO
198  26  26
199  43 RCL
200  12  12
201  65  ×
202  43 RCL
203  24  24
204  39 COS
205  75  -
206  43 RCL
207  29  29
208  65  ×
209  02  2
210  65  ×
211  43 RCL
212  24  24
213  38 SIN
214  95  =
215  42 STO
216  27  27
217  43 RCL
218  07  07
219  85  +
220  43 RCL
221  08  08
222  95  =
223  55  ÷
224  02  2
225  95  =
226  42 STO
227  28  28
228  75  -
229  43 RCL
230  08  08
231  95  =
232  42 STO
233  29  29
234  65  ×
235  4.  RCL
236  24  24
237  39 COS
238  85  +
239  43 RCL
```

240	28	28
241	85	+
242	43	RCL
243	09	09
244	65	×
245	43	RCL
246	24	24
247	38	SIN
248	55	÷
249	02	2
250	95	=
251	42	STO
252	32	32
253	75	-
254	43	RCL
255	07	07
256	75	-
257	43	RCL
258	08	08
259	95	=
260	94	+/-
261	42	STO
262	33	33
263	43	RCL
264	09	09
265	65	×
266	43	RCL
267	24	24
268	39	COS
269	75	-
270	43	RCL
271	29	29
272	65	×
273	02	2
274	65	×
275	43	RCL
276	24	24
277	38	SIN
278	95	=
279	42	STO
280	34	34
281	33	X^2
282	65	×
283	43	RCL
284	57	57
285	85	+
286	43	RCL
287	54	54
288	65	×
289	43	RCL
290	32	32
291	33	X^2
292	85	+
293	02	2
294	65	×
295	43	RCL
296	56	56
297	65	×
298	43	RCL
299	32	32
300	65	×
301	43	RCL
302	33	33
303	85	+
304	43	RCL
305	55	55
306	65	×
307	43	RCL
308	33	33
309	33	X^2
310	95	=
311	42	STO
312	28	28
313	43	RCL
314	58	58
315	65	×
316	43	RCL
317	32	32
318	85	+
319	43	RCL
320	59	59
321	65	×
322	43	RCL
323	33	33
324	85	+
325	02	2
326	65	×
327	53	(
328	43	RCL
329	54	54
330	65	×
331	43	RCL
332	32	32
333	65	×
334	43	RCL
335	25	25
336	85	+
337	43	RCL
338	56	56
339	65	×
340	53	(
341	43	RCL
342	32	32
343	65	×
344	43	RCL
345	26	26
346	85	+
347	43	RCL
348	33	33
349	65	×
350	43	RCL
351	25	25
352	54	)
353	85	+
354	43	RCL
355	55	55
356	65	×
357	43	RCL
358	33	33
359	65	×
360	43	RCL
361	26	26
362	85	+
363	43	RCL
364	57	57
365	65	×
366	43	RCL
367	34	34
368	65	×
369	43	RCL
370	27	27
371	95	=
372	55	÷
373	43	RCL
374	28	28
375	55	÷
376	02	2
377	95	=
378	42	STO
379	29	29
380	01	1
381	75	-
382	43	RCL
383	54	54
384	65	×
385	43	RCL
386	25	25
387	33	X^2
388	75	-
389	02	2
390	65	×
391	43	RCL
392	56	56
393	65	×
394	43	RCL
395	25	25
396	65	×
397	43	RCL
398	26	26
399	75	-
400	43	RCL
401	55	55
402	65	×
403	43	RCL
404	26	26
405	33	X^2
406	75	-
407	43	RCL
408	57	57
409	65	×
410	43	RCL
411	27	27
412	33	X^2
413	75	-
414	43	RCL
415	58	58
416	65	×
417	43	RCL
418	25	25
419	75	-
420	43	RCL
421	59	59
422	65	×
423	43	RCL
424	26	26
425	95	=
426	55	÷
427	43	RCL
428	28	28
429	85	+
430	43	RCL
431	29	29
432	33	X^2
433	95	=
434	34	$\sqrt{x}$
435	42	STO
436	28	28
437	75	-
438	43	RCL
439	29	29
440	95	=
441	42	STO
442	22	22
443	99	PRT
444	75	-
445	02	2
446	65	×
447	43	RCL
448	28	28
449	95	=
450	94	+/-
451	42	STO
452	23	23
453	99	PRT
454	43	RCL
455	22	22
456	91	R/S
457	00	0
458	00	0
459	00	0
460	00	0
461	00	0
462	00	0
463	00	0
464	00	0
465	00	0
466	00	0
467	00	0
468	00	0
469	00	0
470	00	0
471	00	0
472	00	0
473	00	0
474	00	0
475	00	0
476	00	0
477	00	0
478	00	0
479	00	0

R_i

Tape #12 Strength Ratios/Sample Problems

1. -03	ε	1. -03
258.5539-06	ε_x^N	684.99239-06
258.5539-06		-167.88459-06
852.87698-06		0. 00
23.712556-09	ε_x^M	30.278586-09
-11.154947-09		-390.40323-12
17.330573-09		0. 00
-45. 00	θ:(u)	90. 00
184.99191 03	R	143.37864 03
368.44954 03	R'	780.02778 03

-45. 00	00
258.5539-06	01
258.5539-06	02
0. 00	03
0. 00	04
0. 00	05
852.87698-03	06
23.712556-09	07
-11.154947-09	08
17.330573-09	09
258.5539-06	10
258.5539-06	11
852.87698-06	12
23.712556-09	13
-11.154947-09	14
0. 00	15
0. 00	16
0. 00	17
17.330573-06	18
-1.5-06	19
1.125-03	20
1. -03	21
184.99191 03	22
368.44954 03	23
-90. 00	24
-166.38459-06	25
-440.00761-06	26
1.2-15	27
276.72072 03	28
184.99191 03	29
7.17 09	30
0. 00	31
-2.3864819-09	32
14.944091-09	33
34.867503-09	34
0. 00	35
0. 00	36
0. 00	37
0. 00	38
1.0044814 00	39
0. 00	40
125. -06	41
49.487787 09	42
26.880431 09	43
85.73249 09	44
19.710431 09	45
444.44444-21	46
0. 00	47
101.62602-18	48
20.934959-09	49
-500. -03	50
-3.3603243-18	51
0. 00	52
0. 00	53
12.004384 03	54
10.680652 03	55
-3.0691032 03	56
11.117842 03	57
60.646995 00	58
216.59641 00	59

90. 00	00
258.5539-06	01
258.5539-06	02
0. 00	03
426.43849-03	04
-426.43849-03	05
0. 00	06
30.278586-09	07
-390.40323-12	08
0. 00	09
684.99239-06	10
-167.88459-06	11
0. 00	12
12.948013-09	13
-390.40323-12	14
0. 00	15
17.330573-06	16
-82.744711-18	17
0. 00	18
-1.5-06	19
1.125-03	20
1. -03	21
143.37864 03	22
780.02778 03	23
180. 00	24
-166.38459-06	25
-440.00761-06	26
0. 00	27
461.70321 03	28
143.37864 03	29
7.17 09	30
0. 00	31
-390.40323-12	32
30.278586-09	33
0. 00	34
0. 00	35
0. 00	36
0. 00	37
0. 00	38
1.0044814 00	39
0. 00	40
125. -06	41
49.487787 09	42
26.880431 09	43
85.73249 09	44
19.710431 09	45
444.44444-21	46
0. 00	47
101.62602-18	48
20.934959-09	49
-500. -03	50
-3.3603243-18	51
0. 00	52
0. 00	53
12.004384 03	54
10.680652 03	55
-3.0691032 03	56
11.117842 03	57
60.646995 00	58
216.59641 00	59

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