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AIR FORCE MATERIALS LAB WRIGHT-PATTERSON AFB OH F/G 11/4
TI-59 MAGNETIC CARD CALCULATOR SOLUTIONS TO COMPOSITE MATERIALS--ETC(U)
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AFML-TR-79-4040-REV

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(Original report issued April 1979)

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TI-59 MAGNETIC CARD CALCULATOR SOLUTIONS TO COMPOSITE MATERIALS FORMULAS

Stephen W. Tsai
Rodolfo Aoki

Mechanics & Surface Interactions Branch
Nonmetallic Materials Division

JANUARY 1981

TECHNICAL REPORT AFML-TR-79-4040 (Revised)
Final Report for Period January 1980 to December 1980

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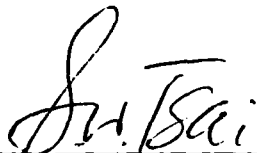
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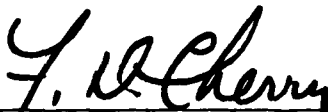
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This technical report has been reviewed and is approved for publication.



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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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.

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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.

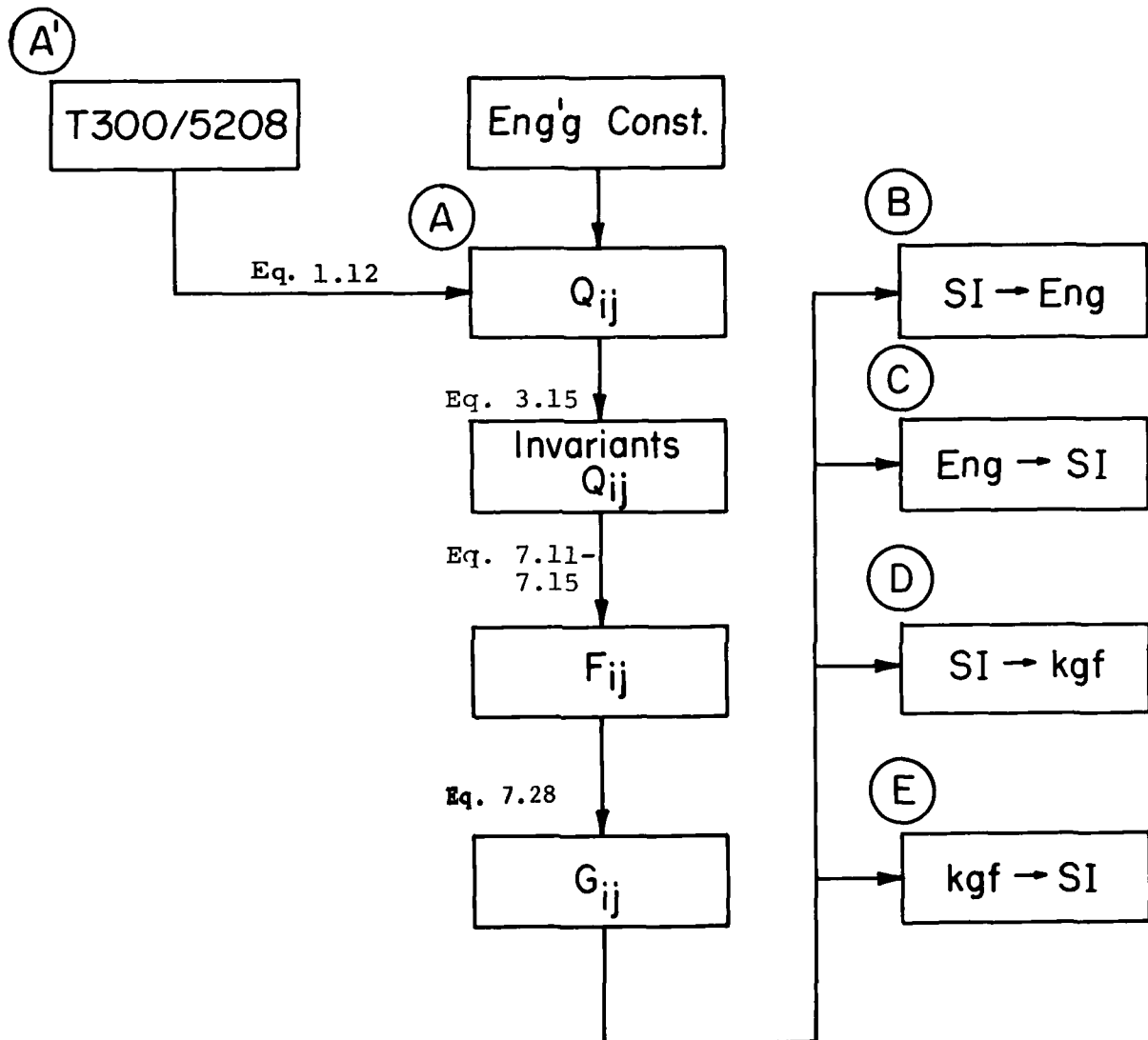
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TAPE #1
PROPERTIES OF UNIDIRECTIONAL COMPOSITES



USER INSTRUCTIONS

TAPE #1: PROPERTIES OF UNIDIRECTIONAL COMPOSITES

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	For T 300/5208 plies, initialize values of $E_x, E_y, \nu_x, \nu_y, E_s, X, X', Y, Y', S, F_{xy}^*$ ($= -1.12$), $\nu_y, \nu_y, \nu_x, \nu_y$, and h_0 in SI. Calculate Q_{ij} invariants $\frac{1}{2}(U_1 + U_4), U_5$ U_2 , and U_3 ; stress failure tensors F_i and F_{ij} ; strain failure tensors G_i and G_{ij} .	--	A'	1.00
2	Convert from SI to English (lb, in, $^{\circ}$ F) units.	--	B	1.00
3	Convert from English to SI units.	--	C	1.00
4	Convert from SI to kgf (kgf, mm, $^{\circ}$ 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 , ..., h_0 , the values may be stored manually in the data registers.	E_x . .	STO 18 . .	E_x . .
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'	B'	C'	D'	E'
Initialize T300/5208				
A	B	C	D	E
Initialize Other Mat'l	SI to English	English to SI	SI to kgf/mm ²	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 v _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

000 75 10L
001 75 H
002 01 1
003 07 7
004 15 RND
005 42 CMS
006 57 ENG
007 01 1
008 03 8
009 01 1
010 52 EE
011 08 8
012 42 STD
013 18 18
014 01 1
015 00 0
016 03 2
017 52 EE
018 03 8
019 42 STD
020 19 19
021 43 1
022 02 2
023 05 3
024 42 STD
025 30 30
026 17 7
027 02 2
028 07 7
029 52 EE
030 07 7
031 42 STD
032 21 21
033 01 1
034 05 5
035 52 EE
036 08 8
037 42 STD
038 13 13
039 42 STD
040 14 14
041 04 4
042 52 EE
043 07 7
044 42 STD
045 15 15
046 02 2
047 04 4
048 04 4
049 52 EE
050 05 5
051 42 STD
052 15 15
053 04 4
054 05 5
055 52 EE
056 05 5
057 42 STD
058 15 15
059 42 STD
060 15 15
061 01 1
062 05 5
063 52 EE
064 04 4
065 07 7
066 42 STD
067 13 13
068 01 1
069 42 STD

New
Mat'l
Q_{ij}

080 24 34
081 33 1
082 06 6
083 42 STD
084 25 25
085 01 1
086 02 2
087 05 5
088 52 EE
089 34 4
090 06 6
091 42 STD
092 41 41
093 75 10L
094 11 11
095 57 ENG
096 43 RCL
097 20 20
098 13 13
099 55 5
100 43 RCL
101 19 19
102 55 5
103 43 RCL
104 18 18
105 75 75
106 01 1
107 35 35
108 44 44
109 35 35
110 42 STD
111 39 39
112 55 5
113 42 RCL
114 18 18
115 35 35
116 42 STD
117 27 27
118 42 STD
119 01 01
120 42 RCL
121 39 39
122 55 5
123 42 RCL
124 19 19
125 35 35
126 42 STD
127 28 28
128 42 STD
129 03 03
130 65 65
131 42 RCL
132 20 20
133 35 35
134 42 STD
135 29 29
136 42 STD
137 03 03
138 42 RCL
139 21 21
140 42 STD
141 30 30
142 55 55
143 04 4
144 75 75
145 02 2
146 55 55
147 42 RCL
148 29 29
149 35 35
150 42 RCL
151 27 27
152 25 25
153 42 RCL
154 28 28
155 35 35
156 55 55
157 08 8
158 45 45
159 42 STD

F_{ij}

160 43 43
161 75 75
162 43 RCL
163 30 30
164 35 35
165 42 STD
166 45 45
167 43 RCL
168 27 27
169 35 35
170 43 RCL
171 28 28
172 35 35
173 02 2
174 35 35
175 43 RCL
176 29 29
177 35 35
178 55 55
179 04 4
180 45 45
181 42 STD
182 42 42
183 42 RCL
184 27 27
185 75 75
186 42 RCL
187 28 28
188 35 35
189 50 50
190 55 55
191 02 2
192 35 35
193 42 STD
194 42 42
195 42 RCL
196 13 13
197 55 55
198 42 RCL
199 14 14
200 35 35
201 35 35
202 42 STD
203 42 42
204 42 RCL
205 13 13
206 35 35
207 75 75
208 42 RCL
209 14 14
210 35 35
211 35 35
212 42 STD
213 42 42
214 42 RCL
215 15 15
216 42 STD
217 42 RCL
218 15 15
219 35 35
220 35 35
221 42 STD
222 42 42
223 42 RCL
224 42 42
225 15 15
226 35 35
227 75 75
228 42 RCL
229 15 15

Tape #1 Properties of Unidirectional

G_{2j}

240	35	1	3
241	35	=	
242	40	STD	
243	44	49	
244	48	ROL	
245	50	30	
246	55	+	
247	48	ROL	
248	51	1	
249	55	=	
250	33	34	
251	40	STD	
252	57	57	
253	43	ROL	
254	48	46	
255	65	+	
256	49	ROL	
257	51	57	
258	53	13	
259	55	+	
260	50	+	
261	55	+	
262	43	ROL	
263	51	51	
264	55	+	
265	53	ROL	
266	54	49	
267	55	49	
268	50	ROL	
269	54	49	
270	55	49	
271	55	49	
272	55	49	
273	55	49	
274	55	49	
275	55	49	
276	55	49	
277	55	49	
278	55	49	
279	55	49	
280	55	49	
281	55	49	
282	55	49	
283	55	49	
284	55	49	
285	55	49	
286	55	49	
287	55	49	
288	55	49	
289	55	49	
290	55	49	
291	55	49	
292	55	49	
293	55	49	
294	55	49	
295	55	49	
296	55	49	
297	55	49	
298	55	49	
299	55	49	
300	55	49	
301	55	49	
302	55	49	
303	55	49	
304	55	49	
305	55	49	
306	55	49	
307	55	49	
308	55	49	
309	55	49	
310	55	49	
311	55	49	
312	55	49	
313	55	49	
314	55	49	

320	37	27
321	65	
322	48	ROL
323	38	38
324	35	
325	48	ROL
326	51	51
327	55	
328	48	ROL
329	39	39
330	38	39
331	35	+
332	40	ROL
333	48	48
334	65	
335	40	ROL
336	48	51
337	49	51
338	48	ROL
339	49	49
340	45	+
341	48	STD
342	55	55
343	48	ROL
344	47	47
345	65	
346	48	ROL
347	49	49
348	45	+
349	48	ROL
350	44	44
351	45	+
352	48	ROL
353	44	44
354	45	+
355	44	STD
356	48	48
357	48	ROL
358	44	44
359	44	44
360	45	+
361	48	ROL
362	49	49
363	45	+
364	48	ROL
365	45	45
366	48	ROL
367	48	18
368	48	+
369	48	STD
370	54	59
371	51	+
372	45	+
373	31	ROL
374	36	LBL
375	12	8
376	05	5
377	00	8
378	09	9
379	05	5
380	05	5
381	42	STD
382	40	40
383	05	5
384	55	+
385	04	4
386	45	+
387	49	PRD
388	20	20
389	49	PRD
390	23	23
391	03	3
392	09	9
393	40	+
394	04	4
395	44	PRD
396	41	41
397	51	58P
398	4	51
399	40	LBL

400	12	1
401	06	6
402	08	8
403	09	9
404	05	5
405	42	STD
406	40	40
407	14	4
408	55	+
409	05	5
410	15	5
411	44	PRD
412	20	20
413	44	PRD
414	33	13
415	00	3
416	14	4
417	48	4
418	34	4
419	25	11
420	44	PRD
421	41	41
422	51	58P
423	44	44
424	51	58P
425	44	44
426	44	44
427	44	44
428	44	44
429	44	44
430	44	44
431	44	44
432	44	44
433	44	44
434	44	44
435	44	44
436	44	44
437	44	44
438	44	44
439	44	44
440	44	44
441	44	44
442	44	44
443	44	44
444	44	44
445	44	44
446	44	44
447	44	44
448	44	44
449	44	44
450	44	44
451	44	44
452	44	44
453	44	44
454	44	44
455	44	44
456	44	44
457	44	44
458	44	44
459	44	44
460	44	44
461	44	44
462	44	44
463	44	44
464	44	44
465	44	44
466	44	44
467	44	44
468	44	44
469	44	44
470	44	44
471	44	44
472	44	44
473	44	44
474	44	44
475	44	44
476	44	44
477	44	44
478	44	44
479	44	44

SI → English

SI → kgf

Conversion

kgf → SI

Eng → SI

TAPE #1 PROPERTIES OF UNIDIRECTIONAL/SAMPLE PROBLEMS

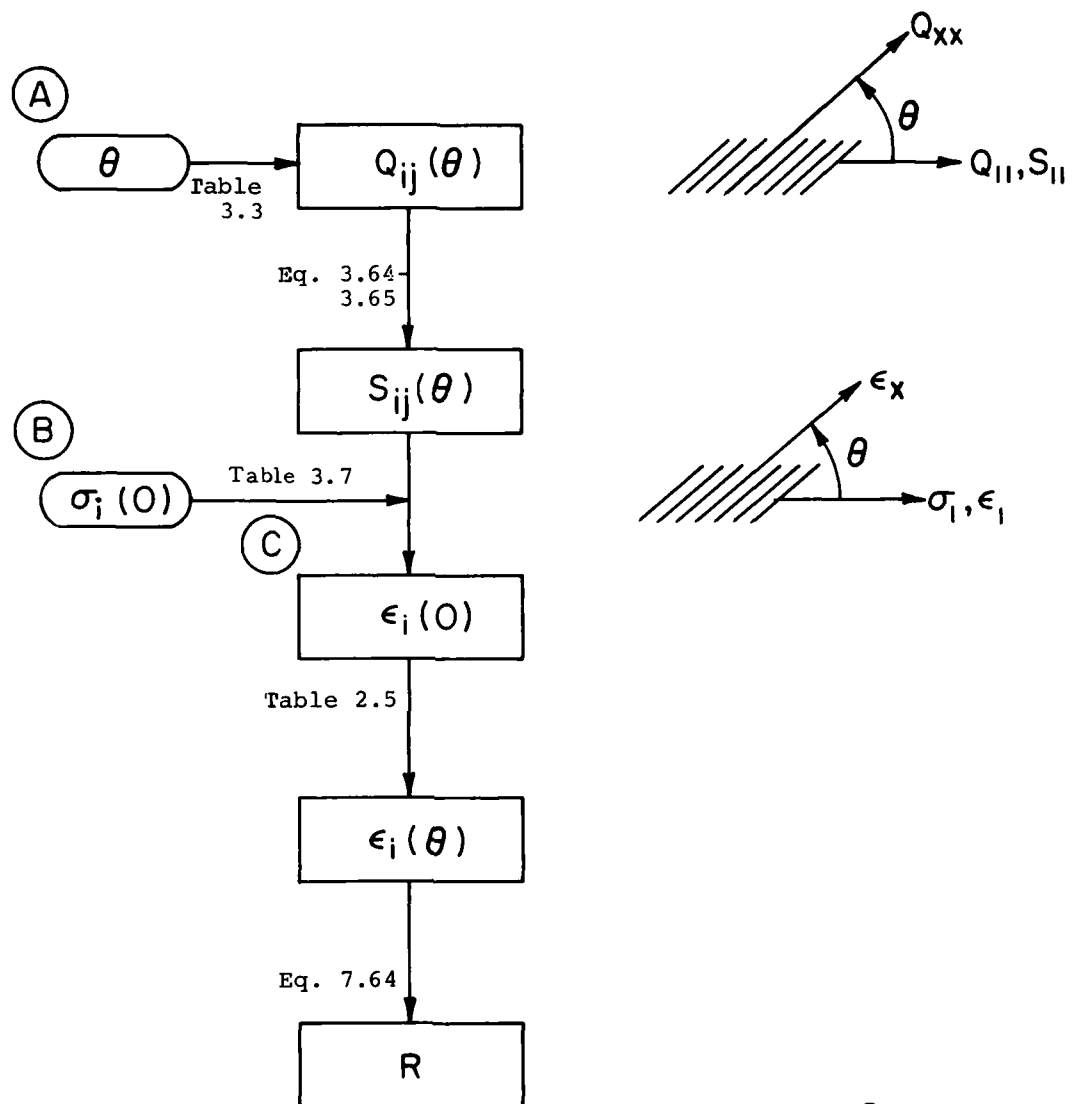
T300/5208

AS/3501

SI	ENG.	Kgf/MM ²	SI	ENG.	
0. 00	0. 00	0. 00	0. 00	0. 00	00
181.31114 04	36.368548 02	18.533246 03	138.78041 04	20.137688 06	01
10.348199 04	1.5005306 00	1.0546543 03	9.0162185 04	1.3076459 06	02
2.8969144 09	420.14858 01	245.30321 00	2.7048656 04	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	51.7135 06	7.5 03	15
346. 04	35.875020 03	25.076453 00	206.85 06	30. 03	16
68. 06	9.863219 03	6.9317023 00	93.0825 06	13.5 03	17
181. 04	26.350906 04	18.450561 03	137.96895 09	20.01 06	18
10.3 09	1.4935361 06	1.049949 03	8.9635 09	1.3 06	19
103. 03	280. -03	280. -03	300. -03	300. -03	20
1. 03	1. 03	730.88685 00	7.10185 09	1.03 06	21
1. 03	5.5555556 -04	10. -09	10. 09	5.5555556 09	22
12.5 -06	6.9444444 -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
138.78041 09	18.533246 03	138.78041 09	138.78041 09	20.137688 06	27
9.0162185 09	1.0546543 03	9.0162185 09	9.0162185 09	1.3076459 06	28
2.7048656 09	245.30321 00	2.7048656 09	2.7048656 09	392.29377 03	29
7.10185 09	730.88685 00	7.10185 09	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
1.0058815 00	1.0044814 00	1.0058815 00	1.0058815 00	1.0058815 00	39
0. 00	145.03263 -06	101.9368 -09	0. 00	145.03263 -06	40
135. -03	4.9325 -03	135. -03	133.24846 -06	5.2499893 -03	41
133.24846 -06	7.177344 06	5.0446366 03	36.30159 09	5.5549804 06	42
36.30159 09	3.8985397 06	2.7401051 03	31.349387 09	3.0963433 06	43
31.349387 09	12.434009 06	8.7382956 03	84.882096 09	9.4100211 06	44
84.882096 09	2.8586557 06	2.0092183 03	14.147437 09	2.0663433 06	45
14.147437 09	21.129344 -12	42.7716 -04	478.37133 -21	22.875737 -12	46
478.37133 -21	0. 00	0. 00	0. 00	0. 00	47
0. 00	4.831405 -09	9.7800915 -03	43.486509 -18	4.4444444 -09	48
43.486509 -18	144.34654 -06	205.37195 -03	14.503261 -09	100. -06	49
14.503261 -09	-500. -03	-500. -03	0. 00	0. 00	50
0. 00	-159.75326 -12	-323.38451 -06	0. 00	0. 00	51
-159.75326 -12	0. 00	0. 00	0. 00	0. 00	52
0. 00	0. 00	0. 00	0. 00	0. 00	53
0. 00	12.004384 03	12.004384 03	9.8704565 03	9.8704565 03	54
12.004384 03	10.680653 03	10.680653 03	7.6032133 03	7.6032133 03	55
10.680653 03	-3.0691032 03	-3.0691032 03	2.4589617 03	2.4589639 03	56
-3.0691032 03	11.117843 03	11.117843 03	5.8111248 03	5.8111248 03	57
11.117843 03	60.646995 00	60.646995 00	39.129377 00	39.129377 00	58
60.646995 00	216.59641 00	216.59641 00	120.76459 00	120.76459 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 counter-clockwise) 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.

OFF-AXIS PROPERTIES OF
UNIDIRECTIONAL COMPOSITES

Tape# 2 Title _____

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 $ Q $	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	STD
	004	00	00
	005	65	-
	006	02	2
	007	95	=
	008	42	STD
	009	39	39
	010	65	-
	011	02	2
	012	95	=
	013	42	STD
	014	40	40
	015	01	1
	016	03	3
	017	56	PRD
Q_{ij}	018	43	RCL
	019	42	42
	020	85	+
	021	43	RCL
	022	42	42
	023	65	-
	024	41	RCL
	025	39	39
	026	19	ODS
	027	65	-
	028	41	RCL
	029	41	41
	030	85	+
	031	41	RCL
	032	40	40
	033	39	ODS
	034	65	-
	035	43	RCL
	036	45	45
	037	95	=
	038	42	STD
	039	27	27
	040	75	-
	041	42	RCL
	042	39	39
	043	39	ODS
	044	65	X
	045	02	2
	046	65	-
	047	43	RCL
	048	44	44
	049	95	=
	050	42	STD
	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	39	ODS
	061	65	-
	062	43	RCL
	063	45	45
	064	95	=
	065	42	STD
	066	29	29
	067	85	+
	068	02	2
	069	65	-
	070	43	RCL
	071	43	43
	072	75	-
	073	43	RCL
	074	42	42
	075	95	=
	076	42	STD
	077	30	30
	078	43	RCL
	079	39	39

	080	38	SIN
	081	55	-
	082	02	2
	083	65	-
	084	43	RCL
	085	41	44
	086	95	=
	087	65	-
	088	43	RCL
	089	40	40
	090	38	STD
	091	75	-
	092	43	RCL
	093	35	45
	094	95	=
	095	43	STD
	096	31	31
	097	75	-
	098	43	RCL
	099	34	39
	100	38	STD
	101	65	-
	102	43	RCL
	103	44	44
	104	95	=
	105	94	+
	106	42	STD
	107	23	33
IQI	108	43	RCL
	109	27	27
	110	65	-
	111	43	RCL
	112	23	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	X ²
	134	75	-
	135	43	RCL
	136	27	27
	137	65	-
	138	43	RCL
	139	32	32
	140	33	X ²
	141	75	-
	142	43	RCL
	143	30	30
	144	65	-
	145	43	RCL
	146	29	29
	147	33	X ²
	148	95	=
	149	42	STD
	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	X ²

	160	95	=
	161	42	STD
	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	X ²
	172	95	=
	173	42	STD
	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	X ²
	184	95	=
	185	42	STD
	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	STD
	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	41	RCL
	211	30	30
	212	95	=
	213	42	STD
	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	33	32
	226	95	=
	227	42	STD
	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

Tape #2 Off-Axis Properties

240	49	PRD
241	37	37
242	49	PRD
243	38	38
244	01	1
245	95	+
246	91	P 3
247	87	LEL
248	12	8
249	40	STD
250	01	01
251	91	P 3
252	40	STD
253	01	02
254	91	P 3
255	40	STD
256	03	01
257	91	P 3
258	87	LEL
259	10	0
260	01	1
261	01	0
262	92	180
263	43	RCL
264	03	00
265	92	+
266	43	RCL
267	37	37
268	92	+
269	43	RCL
270	03	02
271	92	+
272	40	RCL
273	35	35
274	92	+
275	43	RCL
276	01	01
277	65	+
278	43	RCL
279	33	33
280	92	+
281	43	STD
282	10	10
283	43	RCL
284	01	01
285	65	+
286	43	RCL
287	35	35
288	65	+
289	43	RCL
290	03	03
291	92	+
292	43	RCL
293	34	34
294	65	+
295	43	RCL
296	03	03
297	65	+
298	43	RCL
299	36	36
300	95	+
301	40	STD
302	11	11
303	42	RCL
304	01	01
305	65	+
306	43	RCL
307	37	37
308	65	+
309	43	RCL
310	03	03
311	65	+
312	43	RCL
313	35	35
314	65	+
315	43	RCL
316	03	03
317	65	+
318	43	RCL
319	36	36

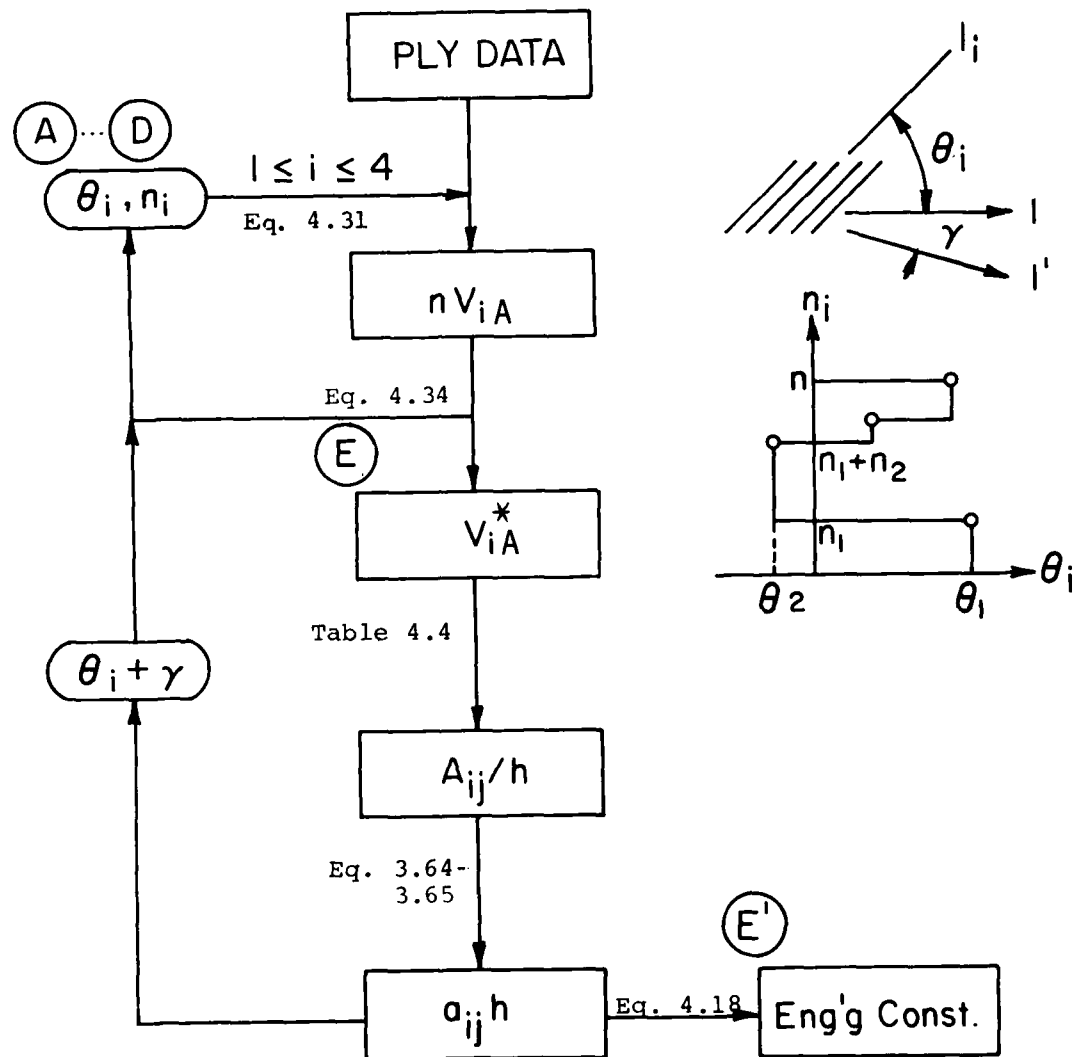
320	95	+
321	40	STD
322	13	13
323	77	LEL
324	14	14
325	40	RCL
326	13	13
327	13	13
328	13	13
329	43	RCL
330	10	10
331	43	RCL
332	43	RCL
333	43	RCL
334	00	00
335	08	11N
336	30	30
337	65	+
338	43	RCL
339	11	11
340	65	+
341	43	RCL
342	00	00
343	43	RCL
344	00	00
345	43	RCL
346	00	00
347	38	11N
348	65	+
349	43	RCL
350	10	10
351	65	+
352	43	RCL
353	43	RCL
354	10	10
355	43	RCL
356	10	10
357	43	RCL
358	11	11
359	43	RCL
360	95	+
361	94	+
362	43	STD
363	08	08
364	40	RCL
365	11	11
366	15	15
367	43	RCL
368	43	RCL
369	10	10
370	95	+
371	43	RCL
372	39	39
373	38	11N
374	65	+
375	43	RCL
376	39	39
377	39	39
378	39	39
379	39	39
380	12	12
381	95	+
382	43	STD
383	04	04
384	78	LEL
385	15	15
386	43	RCL
387	34	34
388	78	78
389	43	RCL
390	01	01
391	39	39
392	39	39
393	43	RCL
394	39	39
395	43	RCL
396	39	39
397	65	+
398	43	RCL
399	65	+
400	65	+

401	43	RCL
402	08	08
403	38	38
404	38	38
405	38	38
406	38	38
407	43	RCL
408	08	08
409	38	38
410	38	38
411	43	RCL
412	38	38
413	43	RCL
414	38	38
415	43	RCL
416	38	38
417	43	RCL
418	38	38
419	43	RCL
420	38	38
421	43	RCL
422	38	38
423	43	RCL
424	38	38
425	43	RCL
426	38	38
427	43	RCL
428	38	38
429	43	RCL
430	38	38
431	43	RCL
432	38	38
433	43	RCL
434	38	38
435	43	RCL
436	38	38
437	43	RCL
438	38	38
439	43	RCL
440	38	38
441	43	RCL
442	38	38
443	43	RCL
444	38	38
445	43	RCL
446	38	38
447	43	RCL
448	38	38
449	43	RCL
450	38	38
451	43	RCL
452	38	38
453	43	RCL
454	38	38
455	43	RCL
456	38	38
457	43	RCL
458	38	38
459	43	RCL
460	38	38
461	43	RCL
462	38	38
463	43	RCL
464	38	38
465	43	RCL
466	38	38
467	43	RCL
468	38	38
469	43	RCL
470	38	38
471	43	RCL
472	38	38
473	43	RCL
474	38	38
475	43	RCL
476	38	38
477	43	RCL
478	38	38
479	43	RCL
480	38	38
481	43	RCL
482	38	38
483	43	RCL
484	38	38
485	43	RCL
486	38	38
487	43	RCL
488	38	38
489	43	RCL
490	38	38
491	43	RCL
492	38	38
493	43	RCL
494	38	38
495	43	RCL
496	38	38
497	43	RCL
498	38	38
499	43	RCL
500	38	38

Tape #2 Off-Axis Properties/Sample Problems

θ	0. 00	15. 00	00	30. 00	45. 00	00
$\sigma_i \{$	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
	0. 00	0. 00	04	0. 00	0. 00	04
	0. 00	0. 00	05	0. 00	0. 00	05
	0. 00	0. 00	06	0. 00	0. 00	06
	0. 00	0. 00	07	0. 00	0. 00	07
	0. 00	0. 00	08	0. 00	0. 00	08
	0. 00	0. 00	09	0. 00	0. 00	09
	0. 00	0. 00	10	0. 00	0. 00	10
	0. 00	0. 00	11	0. 00	0. 00	11
	0. 00	0. 00	12	0. 00	0. 00	12
	0. 00	0. 00	13	0. 00	0. 00	13
	0. 00	0. 00	14	0. 00	0. 00	14
	0. 00	0. 00	15	0. 00	0. 00	15
	0. 00	0. 00	16	0. 00	0. 00	16
	0. 00	0. 00	17	0. 00	0. 00	17
	0. 00	0. 00	18	0. 00	0. 00	18
	0. 00	0. 00	19	0. 00	0. 00	19
	0. 00	0. 00	20	0. 00	0. 00	20
	0. 00	0. 00	21	0. 00	0. 00	21
	0. 00	0. 00	22	0. 00	0. 00	22
	0. 00	0. 00	23	0. 00	0. 00	23
	0. 00	0. 00	24	0. 00	0. 00	24
	0. 00	0. 00	25	0. 00	0. 00	25
	0. 00	0. 00	26	0. 00	0. 00	26
	0. 00	0. 00	27	0. 00	0. 00	27
	0. 00	0. 00	28	0. 00	0. 00	28
	0. 00	0. 00	29	0. 00	0. 00	29
	0. 00	0. 00	30	0. 00	0. 00	30
	0. 00	0. 00	31	0. 00	0. 00	31
	0. 00	0. 00	32	0. 00	0. 00	32
	0. 00	0. 00	33	0. 00	0. 00	33
	0. 00	0. 00	34	0. 00	0. 00	34
	0. 00	0. 00	35	0. 00	0. 00	35
	0. 00	0. 00	36	0. 00	0. 00	36
	0. 00	0. 00	37	0. 00	0. 00	37
	0. 00	0. 00	38	0. 00	0. 00	38
	0. 00	0. 00	39	0. 00	0. 00	39
	0. 00	0. 00	40	0. 00	0. 00	40
	0. 00	0. 00	41	0. 00	0. 00	41
	0. 00	0. 00	42	0. 00	0. 00	42
	0. 00	0. 00	43	0. 00	0. 00	43
	0. 00	0. 00	44	0. 00	0. 00	44
	0. 00	0. 00	45	0. 00	0. 00	45
	0. 00	0. 00	46	0. 00	0. 00	46
	0. 00	0. 00	47	0. 00	0. 00	47
	0. 00	0. 00	48	0. 00	0. 00	48
	0. 00	0. 00	49	0. 00	0. 00	49
	0. 00	0. 00	50	0. 00	0. 00	50
	0. 00	0. 00	51	0. 00	0. 00	51
	0. 00	0. 00	52	0. 00	0. 00	52
	0. 00	0. 00	53	0. 00	0. 00	53
	0. 00	0. 00	54	0. 00	0. 00	54
	0. 00	0. 00	55	0. 00	0. 00	55
	0. 00	0. 00	56	0. 00	0. 00	56
	0. 00	0. 00	57	0. 00	0. 00	57
	0. 00	0. 00	58	0. 00	0. 00	58
	0. 00	0. 00	59	0. 00	0. 00	59

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 calculate V_{1A}^* , V_{2A}^* , V_{3A}^* and V_{4A}^* for each ply and sum them, and calculate n . Since $1 \leq i \leq 4$, values for nonexistent plies need not be entered, i.e. for a $[0/90]$ laminate, $i=3$ and 4 can be skipped.	θ_1	A	θ_1
		n_1	R/S	$2n_1$
		θ_2	B	θ_2
		n_2	R/S	$2(n_1 + n_2)$
		θ_3	C	θ_3
		n_3	R/S	$2(n_1 + n_2 + n_3)$
		θ_4	D	θ_4
		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_1^0
		--	R/S	E_2^0
		--	R/S	ν_{12}^0
		--	R/S	E_6^0

Alternative A

1A	Rotate entire laminate by γ ; ** n_i remain the same	γ	A'	$2n_1$
		--	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_1^0
		--	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 $\theta_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	080	39	COS	160	43	ROL
	001	11	R	081	65	+	161	48	48
	002	57	ENG	082	47	FOL	162	65	+
	003	42	STD	083	40	40	163	43	ROL
	004	12	+	084	85	+	164	45	45
	005	00	0	085	43	540	165	95	=
	006	42	STD	086	47	47	166	43	STD
	007	46	46	087	43	FOL	167	57	57
	008	43	STD	088	15	+	168	75	+
	009	47	47	089	15	114	169	03	3
	010	43	STD	090	65	+	170	55	55
	011	43	48	091	43	FOL	171	43	ROL
	012	42	STD	092	40	40	172	47	47
	013	45	48	093	85	+	173	65	+
	014	42	STD	094	44	114	174	43	ROL
	015	50	50	095	43	114	175	44	44
	016	43	ROL	096	03	+	176	95	=
	017	13	13	097	43	FFD	177	43	STD
	018	91	R/S	098	39	114	178	23	23
	019	42	STD	099	42	FOL	179	43	ROL
	020	14	14	100	35	114	180	43	43
	021	43	STD	101	34	COS	181	75	+
	022	40	40	102	65	+	182	43	ROL
	023	44	SUM	103	41	FOL	183	43	43
	024	46	46	104	41	40	184	75	+
	025	43	ROL	105	95	+	185	43	ROL
	026	11	13	106	44	SUM	186	43	43
	027	71	SEP	107	43	48	187	65	+
	028	13	13	108	43	ROL	188	43	ROL
θ_2, n_2	029	43	LBL	109	39	114	189	43	43
	030	11	0	110	39	114	190	55	=
	031	43	STD	111	65	+	191	43	STD
	032	75	15	112	43	ROL	192	23	23
	033	91	R/S	113	40	40	193	75	+
	034	43	STD	114	95	=	194	43	ROL
	035	15	15	115	44	SUM	195	43	43
	036	43	STD	116	50	50	196	85	+
	037	40	40	117	43	ROL	197	03	3
	038	44	SUM	118	46	46	198	65	+
	039	45	45	119	65	+	199	43	ROL
	040	43	ROL	120	03	3	200	43	43
	041	15	15	121	95	=	201	95	=
	042	71	SEP	122	91	R/S	202	43	STD
	043	33	13	123	76	LBL	203	30	30
θ_3, n_3	044	76	LBL	124	15	E	204	43	ROL
	045	13	0	125	01	1	205	65	49
	046	43	STD	126	03	3	206	65	+
	047	17	17	127	66	PHO	207	43	ROL
	048	91	R/S	128	43	ROL	208	44	44
	049	43	STD	129	46	46	209	55	+
	050	13	13	130	35	1	210	65	+
	051	43	STD	131	43	FFD	211	65	+
	052	40	40	132	41	41	212	43	ROL
	053	44	SUM	133	44	FFD	213	50	50
	054	46	46	134	48	41	214	75	+

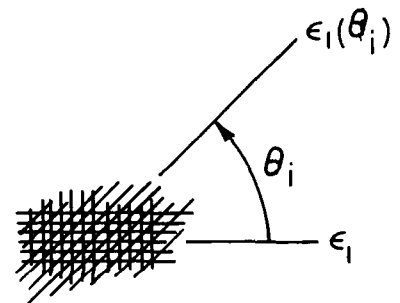
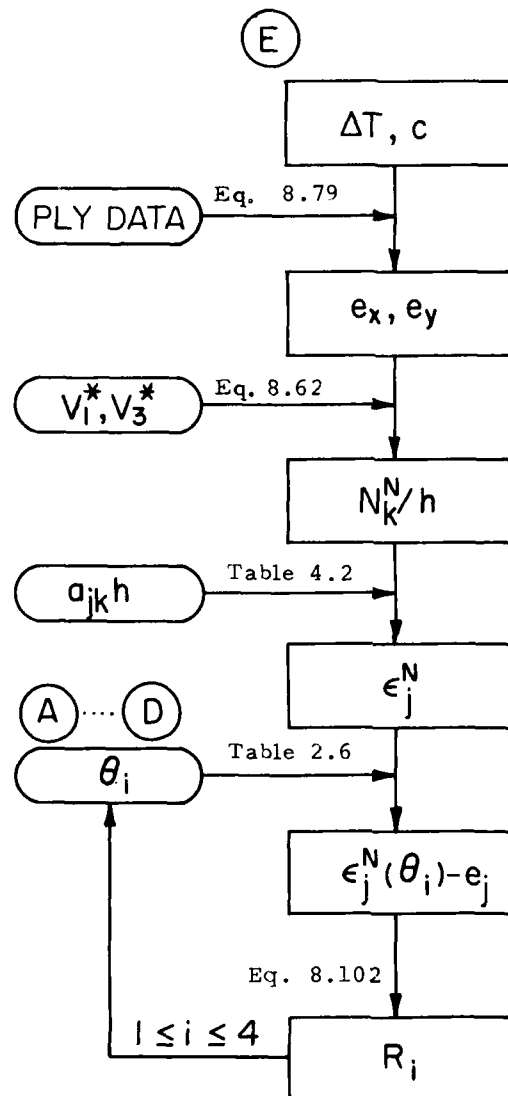
Tape #3 In-Plane Stiffness

240	85	+		320	43	RCL		400	15	15
241	43	RCL		321	31	31		401	44	SUM
242	29	29		322	95	=		402	17	17
243	65	X		323	42	STD		403	44	SUM
244	43	RCL		324	37	37		404	19	19
245	31	31		325	43	RCL		405	00	0
246	65	X		326	31	31		406	42	STD
247	43	RCL		327	65	X		407	46	46
248	32	32		328	43	RCL		408	42	STD
249	65	X		329	32	32		409	47	47
250	02	2		330	75	-		410	42	STD
251	75	-		331	43	RCL		411	48	48
252	43	RCL		332	29	29		412	42	STD
253	28	28		333	65	X		413	49	49
254	65	X		334	43	RCL		414	42	STD
255	43	RCL		335	30	30		415	50	50
256	31	31		336	95	=		416	43	RCL
257	33	X ²		337	42	STD		417	14	14
258	75	-		338	35	35		418	42	STD
259	43	RCL		339	43	RCL		419	40	40
260	27	27		340	29	29		420	44	SUM
261	65	X		341	65	X		421	46	46
262	43	RCL		342	43	RCL		422	43	RCL
263	32	32		343	31	31		423	13	13
264	33	X ²		344	75	-		424	71	SBR
265	75	-		345	43	RCL		425	33	X ²
266	43	RCL		346	27	27		426	76	LBL
267	30	30		347	65	X		427	17	B ⁺
268	65	X		348	43	RCL		428	43	RCL
269	43	RCL		349	32	32		429	16	16
270	29	29		350	95	=		430	42	STD
271	33	X ²		351	42	STD		431	40	40
272	95	=		352	38	38		432	44	SUM
273	42	STD		353	43	RCL		433	46	46
274	39	39		354	39	39		434	43	RCL
275	43	RCL		355	35	1/X		435	15	15
276	28	28		356	49	PRD		436	71	SBR
277	65	X		357	33	33		437	33	X ²
278	43	RCL		358	49	PRD		438	76	LBL
279	30	30		359	34	34		439	18	C ⁺
280	75	-		360	49	PRD		440	43	RCL
281	43	RCL		361	35	35		441	18	18
282	32	32		362	49	PRD		442	42	STD
283	33	X ²		363	36	36		443	40	40
284	95	=		364	49	PRD		444	44	SUM
285	42	STD		365	37	37		445	46	46
286	33	33		366	49	PRD		446	43	RCL
287	43	RCL		367	38	38		447	17	17
288	27	27		368	01	1		448	71	SBR
289	65	X		369	95	=		449	33	X ²
290	43	RCL		370	91	R/S		450	76	LBL
291	28	28		371	76	LBL		451	19	D ⁺
292	75	-		372	10	E ⁺		452	43	RCL
293	43	RCL		373	43	RCL		453	20	20
294	29	29		374	33	33		454	42	STD
295	33	X ²		375	35	1/X		455	40	40
296	95	=		376	91	R/S		456	44	SUM
297	42	STD		377	43	RCL		457	46	46
298	36	36		378	34	34		458	43	RCL
299	43	RCL		379	35	1/X		459	19	19
300	27	27		380	91	R/S		460	71	SBR
301	65	X		381	43	RCL		461	33	X ²
302	43	RCL		382	35	35		462	00	0
303	30	30		383	55	-		463	00	0
304	75	-		384	43	RCL		464	00	0
305	43	RCL		385	33	33		465	00	0
306	31	31		386	95	=		466	00	0
307	33	X ²		387	94	+/-		467	00	0
308	95	=		388	91	R/S		468	00	0
309	42	STD		389	43	RCL		469	00	0
310	34	34		390	36	36		470	00	0
311	43	RCL		391	35	1/X		471	00	0
312	29	29		392	91	R/S		472	00	0
313	65	X		393	76	LBL		473	00	0
314	43	RCL		394	16	B ⁺		474	00	0
315	32	32		395	42	STD		475	00	0
316	75	-		396	00	00		476	00	0
317	43	RCL		397	44	SUM		477	00	0
318	28	28		398	13	13		478	00	0
319	65	X		399	44	SUM		479	00	0

Tape #3 In-Plane Stiffness/Sample Problems

	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
	10.346159	09	02	10.346159	09	02	10.346159	09	02	10.346159	09
	2.8969244	09	03	2.8969244	09	03	2.8969244	09	03	2.8969244	09
	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
n_i	1.00	14		1.00	14		1.00	14		1.00	14
	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
	181.09	18		181.09	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
	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
	500.-06	26		500.-06	26		750.-06	26		1.-03	26
R	76.368218	09	27	56.657787	09	27	76.368218	09	27	76.368218	09
	76.368218	09	28	56.657787	09	28	76.368218	09	28	76.368218	09
A_{ij}/R	2.8969244	09	29	42.317787	09	29	22.607356	09	29	22.607356	09
	7.17	09	30	46.590862	09	30	26.880431	09	30	26.880431	09
	0.00	31		0.00	31		0.00	31		0.00	31
	0.00	32		0.00	32		0.00	32		0.00	32
$a_{ij}h$	10.417611	-12	33	39.419255	-12	33	14.352198	-12	33	14.352198	-12
	10.417611	-12	34	39.419255	-12	34	14.352198	-12	34	14.352198	-12
	-314.10757	-15	35	-39.815752	-12	35	-4.2486946	-12	35	-4.2486946	-12
	139.47001	-12	36	21.463436	-12	36	37.201784	-12	36	37.201784	-12
	0.00	37		0.00	37		0.00	37		0.00	37
	0.00	38		0.00	38		0.00	38		0.00	38
	66.126884	30	39	66.126884	30	39	143.0311	30	39	143.0311	30
	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
	26.880431	09	43	26.880431	09	43	26.880431	09	43	26.880431	09
	85.73249	09	44	85.73249	09	44	85.73249	09	44	85.73249	09
	19.710431	09	45	19.710431	09	45	19.710431	09	45	19.710431	09
	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
	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
	10.680652	03	55	10.680652	03	55	10.680652	03	55	10.680652	03
	-3.0691032	03	56	-3.0691032	03	56	-3.0691032	03	56	-3.0691032	03
	11.117842	03	57	11.117842	03	57	11.117842	03	57	11.117842	03
	60.646995	00	58	60.646995	00	58	60.646995	00	58	60.646995	00
	216.59641	00	59	216.59641	00	59	216.59641	00	59	216.59641	00

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



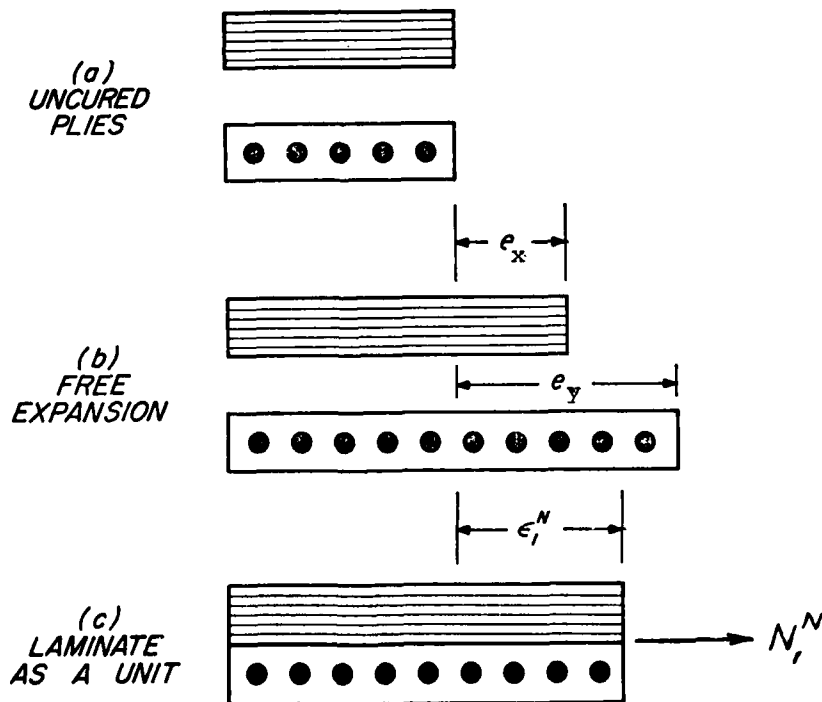
USER INSTRUCTIONS

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.



IN-PLANE NONMECHANICAL STRAINS
OF SYMMETRIC LAMINATES

Tape# 4 Title _____

A'	B'	C'	D'	E'
A R_1	B R_2	C R_3	D R_4	E $\Delta T, c$
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 $V_{2A}^*, \Delta T$	
04 N_1^N/h	19 θ_4	34 $a_{22}h$	49 V_{3A}^*	
05 N_2^N/h	20 n_4	35 $a_{12}h$	50 V_{4A}^*, c	
06 N_6^N/h	21 $2\theta_i$	36 $a_{66}h$	51	
07 $e_1^N(\theta_i) - e_x$	22 α_x	37 $a_{16}h$	52 e_x	
08 $e_2^N(\theta_i) - e_y$	23 α_y	38 $a_{26}h$	53 e_y	
09 $e_6^N(\theta_i)$	24 β_x	39 $\dots R'_4$	54 G_{xx}	
10 e_1^N	25 β_y	40 $\dots R_4$	55 G_{yy}	
11 e_2^N	26 h	41	56 G_{xy}	
12 e_6^N	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	

Tape #4 In-Plane Nonmechanical

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 X
015 43 RCL
016 22 22
017 95 =
018 42 STD
019 52 52
020 08 8
021 66 PAU
022 43 RCL
023 48 48
024 65 X
025 43 RCL
026 33 33
027 85 +
028 43 RCL
029 50 50
030 65 X
031 43 RCL
032 35 35
033 95 =
034 42 STD
035 53 53
036 65 X
037 43 RCL
038 03 03
039 85 +
040 43 RCL
041 52 52
042 65 X
043 43 RCL
044 01 01
045 95 =
046 42 STD
047 39 39
048 43 RCL
049 52 52
050 65 X
051 43 RCL
052 03 03
053 85 +
054 43 RCL
055 53 53
056 65 X
057 43 RCL
058 02 02
059 95 =
060 42 STD
061 40 40
062 85 +
063 43 RCL
064 39 39
065 95 =
066 55 -
067 02 2
068 95 =
069 42 STD
070 39 39
071 75 -
072 43 RCL
073 40 40
074 95 =
075 42 STD
076 40 40
077 65 -
078 43 RCL
079 47 47

080 85 +
081 43 RCL
082 39 39
083 95 =
084 42 STD
085 04 04
086 75 -
087 02 2
088 65 X
089 43 RCL
090 47 47
091 65 X
092 43 RCL
093 40 40
094 95 =
095 42 STD
096 05 05
097 43 RCL
098 48 48
099 65 X
100 43 RCL
101 40 40
102 95 =
103 94 +/-
104 42 STD
105 06 06
106 65 X
107 43 RCL
108 37 37
109 85 +
110 43 RCL
111 04 04
112 65 X
113 43 RCL
114 33 33
115 85 +
116 43 RCL
117 05 05
118 65 X
119 43 RCL
120 35 35
121 95 =
122 42 STD
123 10 10
124 43 RCL
125 04 04
126 65 X
127 43 RCL
128 35 35
129 85 +
130 43 RCL
131 05 05
132 65 X
133 43 RCL
134 34 34
135 85 +
136 43 RCL
137 06 06
138 65 X
139 43 RCL
140 38 38
141 95 =
142 42 STD
143 11 11
144 43 RCL
145 04 04
146 65 X
147 43 RCL
148 37 37
149 85 +
150 43 RCL
151 05 05
152 65 X
153 43 RCL
154 38 38
155 85 +
156 43 RCL
157 06 06
158 65 X
159 43 RCL

ϵ_j^N

160 36 36
161 95 =
162 42 STD
163 12 12
164 01 1
165 95 =
166 91 P.S.
167 76 LBL
168 11 11
169 43 RCL
170 13 13
171 71 SBR
172 35 1/X
173 42 STD
174 27 27
175 43 RCL
176 40 40
177 42 STD
178 30 30
179 91 P.S.
180 76 LBL
181 12 12
182 43 RCL
183 15 15
184 71 SBR
185 35 1/X
186 42 STD
187 28 28
188 43 RCL
189 40 40
190 42 STD
191 31 31
192 91 P.S.
193 76 LBL
194 13 13
195 43 RCL
196 17 17
197 71 SBR
198 35 1/X
199 42 STD
200 29 29
201 43 RCL
202 40 40
203 42 STD
204 32 32
205 91 P.S.
206 76 LBL
207 14 14
208 43 RCL
209 19 19
210 71 SBR
211 35 1/X
212 42 STD
213 39 39
214 43 RCL
215 40 40
216 91 P.S.
217 76 LBL
218 35 1/X
219 65 X
220 02 2
221 95 =
222 42 STD
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 STD
237 39 39
238 75 -
239 43 RCL

R_1

R_2

R_3

R_4

$\epsilon_j^N(\theta)$
- e_j

Tape #4 In-Plane Nonmechanical

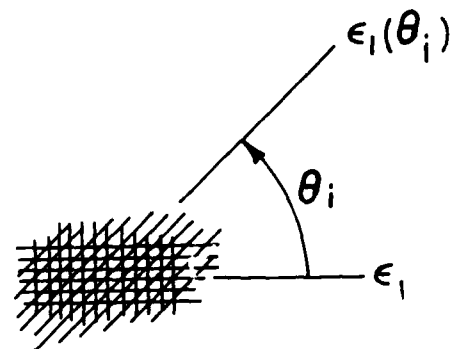
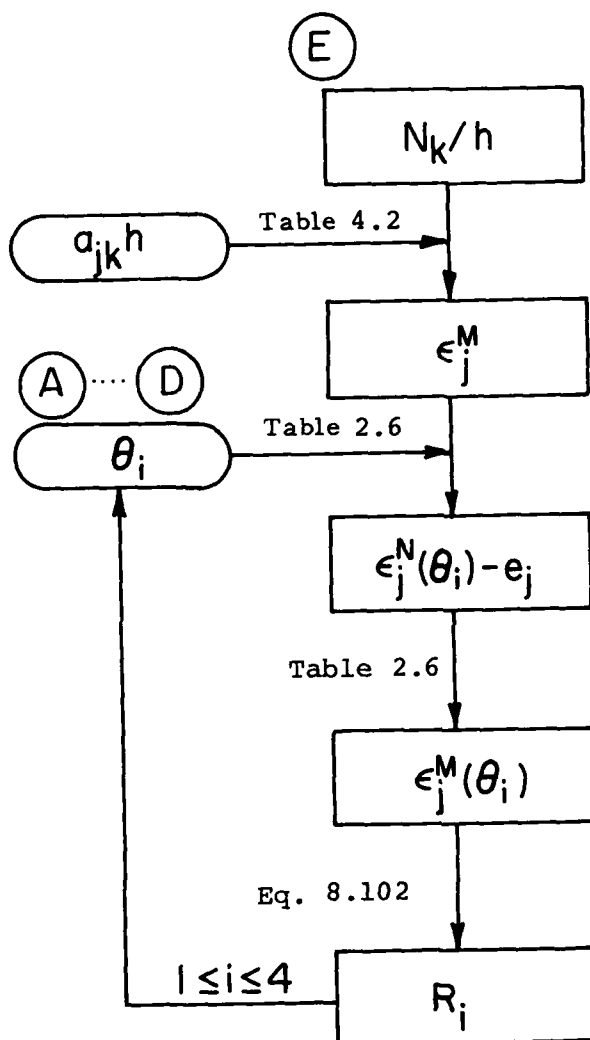
240	11	11	320	07	07
241	95	=	321	65	x
242	42	STD	322	43	RCL
243	40	40	323	08	08
244	65	x	324	85	+
245	43	RCL	325	43	RCL
246	21	21	326	55	55
247	39	CDS	327	65	x
248	85	+	328	43	RCL
249	43	RCL	329	08	08
250	39	39	330	33	X ²
251	85	+	331	95	=
252	53	(	332	42	STD
253	43	RCL	333	39	39
254	12	12	334	43	RCL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

R_i

Tape #4 In-Plane Nonmechanical / sample problems

	0. 00	00		0. 00	00		0. 00	00
	181.81114 09	01		181.81114 09	01		181.81114 09	01
	10.346159 09	02		10.346159 09	02		10.346159 09	02
	2.8969244 09	03		2.8969244 09	03		2.8969244 09	03
	-12.553922 06	04		19.864625 06	04		7.3107032 06	04
	-12.553922 06	05		19.864625 06	05		7.3107032 06	05
	0. 00	06		0. 00	06		0. 00	06
	-125.33858-06	07		200.7023-06	07		75.363712-06	07
	1.7481614-03	08		-2.7992977-03	08		-1.0511363-03	08
	0. 00	09		0. 00	09		0. 00	09
	-126.83858-06	10		200.7023-06	10		73.863712-06	10
	-126.83858-06	11		200.7023-06	11		73.863712-06	11
	0. 00	12		0. 00	12		0. 00	12
θ_i	0. 00	13		0. 00	13		0. 00	13
n_i	1. 00	14		1. 00	14		1. 00	14
	90. 00	15		90. 00	15		90. 00	15
	1. 00	16		1. 00	16		1. 00	16
	68. 06	17		68. 06	17		68. 06	17
	181. 09	18		181. 09	18		181. 09	18
	10.3 09	19		10.3 09	19		10.3 09	19
	280. -03	20		280. -03	20		280. -03	20
	180. 00	21		180. 00	21		180. 00	21
	10. -09	22		10. -09	22		10. -09	22
	12.5-06	23		12.5-06	23		12.5-06	23
	0. 00	24		0. 00	24		0. 00	24
	600. -03	25		600. -03	25		600. -03	25
	500. -06	26		500. -06	26		500. -06	26
	13.092402 00	27		1.395767 00	27		3.7170891 00	27
	13.092402 00	28		1.395767 00	28		3.7170891 00	28
	2.8969244 09	29		2.8969244 09	29		2.8969244 09	29
	2.2350152 00	30		8.1762053 00	30		21.774182 00	30
	2.2350152 00	31		8.1762053 00	31		21.774182 00	31
	0. 00	32		0. 00	32		0. 00	32
	10.417611-12	33		10.417611-12	33		10.417611-12	33
	10.417611-12	34		10.417611-12	34		10.417611-12	34
	-314.10757-15	35		-314.10757-15	35		-314.10757-15	35
	139.47001-12	36		139.47001-12	36		139.47001-12	36
	0. 00	37		0. 00	37		0. 00	37
	0. 00	38		0. 00	38		0. 00	38
	7.6637088 00	39		4.7859861 00	39		12.745636 00	39
	2.2350152 00	40		8.1762053 00	40		21.774182 00	40
	125. -06	41		125. -06	41		125. -06	41
	49.487787 09	42		49.487787 09	42		49.487787 09	42
	26.880431 09	43		26.880431 09	43		26.880431 09	43
	85.73249 09	44		85.73249 09	44		85.73249 09	44
	19.710431 09	45		19.710431 09	45		19.710431 09	45
	2. 00	46		2. 00	46		2. 00	46
	0. 00	47		0. 00	47		0. 00	47
ΔT	-150. 00	48		0. 00	48		-150. 00	48
	0. 00	49		0. 00	49		0. 00	49
c	0. 00	50		5. -03	50		5. -03	50
	-3.3603243-18	51		-3.3603243-18	51		-3.3603243-18	51
	-1.5-06	52		0. 00	52		-1.5-06	52
	-1.875-03	53		3. -03	53		1.125-03	53
	12.004384 03	54		12.004384 03	54		12.004384 03	54
	10.680652 03	55		10.680652 03	55		10.680652 03	55
	-3.0691032 03	56		-3.0691032 03	56		-3.0691032 03	56
	11.117842 03	57		11.117842 03	57		11.117842 03	57
	60.646995 00	58		60.646995 00	58		60.646995 00	58
	216.59641 00	59		216.59641 00	59		216.59641 00	59

TAPE #5 IN-PLANE STRENGTH OF SYMMETRIC LAMINATES

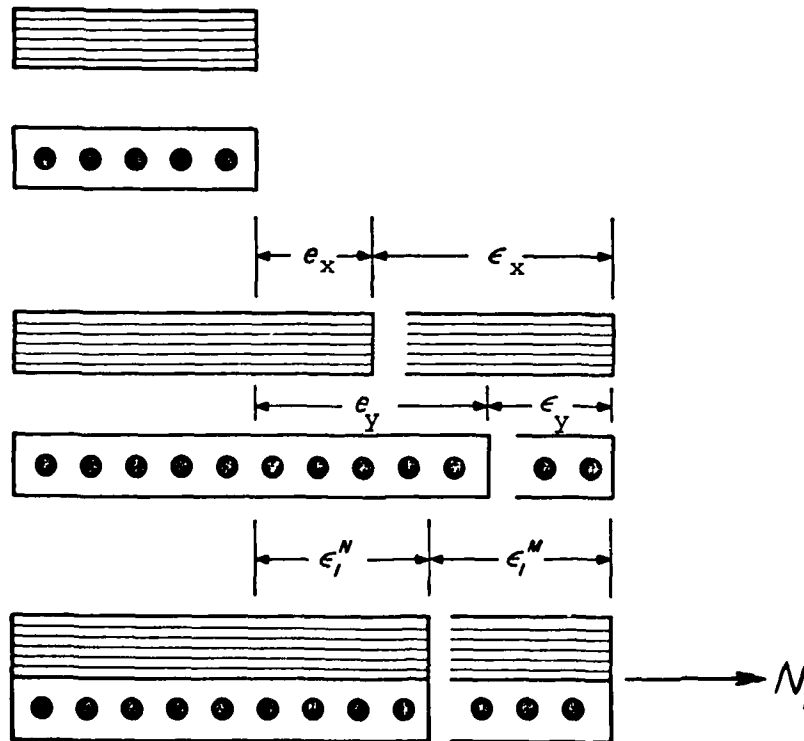


USER INSTRUCTIONS

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 ϵ_j^M . Unit stresses such as [1,0,0] can be entered here. The resulting S values are the allowables.	N_1/h N_2/h N_6/h	E R/S R/S	N_1/h N_2/h 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 B C D	R_1 R_2 R_3 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 $\Delta T = c = 0$.



IN-PLANE STRENGTH OF
SYMMETRIC LAMINATES

Tape# 5 Title _____

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	

Tape #5 In-Plane Strength

N_k/h	001	40	FOL
	002	40	FOL
	003	40	FOL
	004	40	FOL
	005	40	FOL
	006	40	FOL
	007	40	FOL
	008	40	FOL
	009	40	FOL
	010	40	FOL
	011	40	FOL
	012	40	FOL
	013	40	FOL
	014	40	FOL
	015	40	FOL
	016	40	FOL
	017	40	FOL
	018	40	FOL
	019	40	FOL
	020	40	FOL
	021	40	FOL
	022	40	FOL
	023	40	FOL
	024	40	FOL
	025	40	FOL
	026	40	FOL
	027	40	FOL
	028	40	FOL
	029	40	FOL
	030	40	FOL
	031	40	FOL
	032	40	FOL
	033	40	FOL
	034	40	FOL
	035	40	FOL
	036	40	FOL
	037	40	FOL
	038	40	FOL
	039	40	FOL
	040	40	FOL
	041	40	FOL
	042	40	FOL
	043	40	FOL
	044	40	FOL
	045	40	FOL
	046	40	FOL
	047	40	FOL
	048	40	FOL
	049	40	FOL
	050	40	FOL
	051	40	FOL
	052	40	FOL
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	066	40	FOL
	067	40	FOL
	068	40	FOL
	069	40	FOL
	070	40	FOL
	071	40	FOL
	072	40	FOL
	073	40	FOL
	074	40	FOL
	075	40	FOL
	076	40	FOL
	077	40	FOL
	078	40	FOL
	079	40	FOL

R_2	080	40	FOL
	081	40	FOL
	082	40	FOL
	083	40	FOL
	084	40	FOL
	085	40	FOL
	086	40	FOL
	087	40	FOL
	088	40	FOL
	089	40	FOL
	090	40	FOL
	091	40	FOL
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	146	40	FOL
	147	40	FOL
	148	40	FOL
	149	40	FOL
	150	40	FOL
	151	40	FOL
	152	40	FOL
	153	40	FOL
	154	40	FOL
	155	40	FOL
	156	40	FOL
	157	40	FOL
	158	40	FOL
	159	40	FOL

R_3	160	40	FOL
	161	40	FOL
	162	40	FOL
	163	40	FOL
	164	40	FOL
	165	40	FOL
	166	40	FOL
	167	40	FOL
	168	40	FOL
	169	40	FOL
	170	40	FOL
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	183	40	FOL
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	185	40	FOL
	186	40	FOL
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	238	40	FOL
	239	40	FOL
	240	40	FOL
	241	40	FOL
	242	40	FOL
	243	40	FOL
	244	40	FOL
	245	40	FOL
	246	40	FOL
	247	40	FOL
	248	40	FOL
	249	40	FOL
	250	40	FOL

Tape #5 In-Plane Strength

240	85	+	320	85	+	400	31	31
241	43	FCL	321	43	FCL	401	75	-
242	39	39	322	59	59	402	43	FCL
243	85	+	323	65	x	403	55	55
244	43	FCL	324	43	FCL	404	43	-
245	09	09	325	38	38	405	43	FCL
246	65	x	326	85	+	406	31	31
247	43	FCL	327	02	2	407	33	33
248	21	21	328	65	x	408	75	-
249	38	SIN	329	53	-	409	43	FCL
250	55	-	330	43	FCL	410	57	57
251	02	2	331	54	54	411	65	-
252	95	=	332	65	x	412	43	FCL
253	42	STD	333	43	FCL	413	33	32
254	27	27	334	27	27	414	33	33
255	75	-	335	65	x	415	75	-
256	43	FCL	336	43	FCL	416	43	FCL
257	07	07	337	30	30	417	58	58
258	75	-	338	85	+	418	60	x
259	43	FCL	339	43	FCL	419	43	FCL
260	08	08	340	56	56	420	30	30
261	95	=	341	65	x	421	75	-
262	94	+/-	342	53	-	422	43	FCL
263	40	STD	343	43	FCL	423	59	59
264	38	28	344	27	27	424	65	x
265	43	FCL	345	45	x	425	43	FCL
266	09	09	346	43	FCL	426	31	31
267	65	x	347	31	31	427	95	=
268	43	FCL	348	27	+	428	65	-
269	31	31	349	43	FCL	429	43	FCL
270	39	09	350	38	28	430	39	39
271	75	-	351	65	x	431	85	+
272	43	FCL	352	43	FCL	432	43	FCL
273	40	40	353	30	30	433	40	40
274	65	-	354	54	-	434	38	33
275	02	2	355	85	+	435	95	=
276	65	x	356	43	FCL	436	34	34
277	43	FCL	357	55	55	437	43	STD
278	31	31	358	65	x	438	39	39
279	38	SIN	359	43	FCL	439	75	-
280	95	=	360	38	28	440	43	FCL
281	42	STD	361	65	x	441	40	40
282	29	29	362	43	FCL	442	95	=
283	32	32	363	31	31	443	43	STD
284	65	x	364	85	+	444	40	40
285	43	FCL	365	43	FCL	445	75	-
286	57	57	366	57	57	446	02	2
287	35	+	367	65	x	447	65	x
288	43	FCL	368	43	FCL	448	43	FCL
289	54	54	369	29	29	449	34	39
290	65	x	370	65	x	450	95	=
291	43	FCL	371	43	FCL	451	34	+
292	27	27	372	32	32	452	32	RTN
293	32	32	373	85	=	453	00	0
294	85	+	374	55	-	454	00	0
295	02	2	375	43	FCL	455	00	0
296	65	x	376	39	39	456	00	0
297	40	FCL	377	55	+	457	00	0
298	56	56	378	02	2	458	00	0
299	65	x	379	95	=	459	00	0
300	43	FCL	380	42	STD	460	00	0
301	37	27	381	40	40	461	00	0
302	65	x	382	01	1	462	00	0
303	43	FCL	383	75	-	463	00	0
304	28	28	384	43	FCL	464	00	0
305	85	+	385	54	54	465	00	0
306	43	FCL	386	65	x	466	02	0
307	55	55	387	43	FCL	467	00	0
308	65	x	388	30	30	468	00	0
309	43	FCL	389	33	33	469	00	0
310	28	28	390	75	-	470	00	0
311	33	33	391	02	2	471	00	0
312	95	=	392	65	x	472	00	0
313	42	STD	393	43	FCL	473	00	0
314	39	39	394	56	56	474	00	0
315	43	FCL	395	65	x	475	00	0
316	58	58	396	43	FCL	476	00	0
317	65	x	397	30	30	477	00	0
318	43	FCL	398	65	x	478	00	0
319	27	27	399	43	FCL	479	00	0

R_i

Tape #5 In-Plane Strength/Sample Problems

	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
	7.3137032 06	0. 00	04	7.3137032 06	0. 00	04
	7.3137032 06	0. 00	05	7.3137032 06	0. 00	05
	0. 00	0. 00	06	0. 00	0. 00	06
	10.417611-12	10.417611-12	07	39.919255-12	39.919255-12	07
	-314.10757-15	-314.10757-15	08	-29.815752-12	-29.815752-12	08
	0. 00	0. 00	09	0. 00	0. 00	09
	73.363712-06	0. 00	10	73.363712-06	0. 00	10
	73.363712-06	0. 00	11	73.363712-06	0. 00	11
	0. 00	0. 00	12	0. 00	0. 00	12
θ_i	0. 00	0. 00	13	45. 00	45. 00	13
	1. 00	1. 00	14	1. 00	1. 00	14
	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
	75.363712-06	0. 00	30	75.363712-06	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_i	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

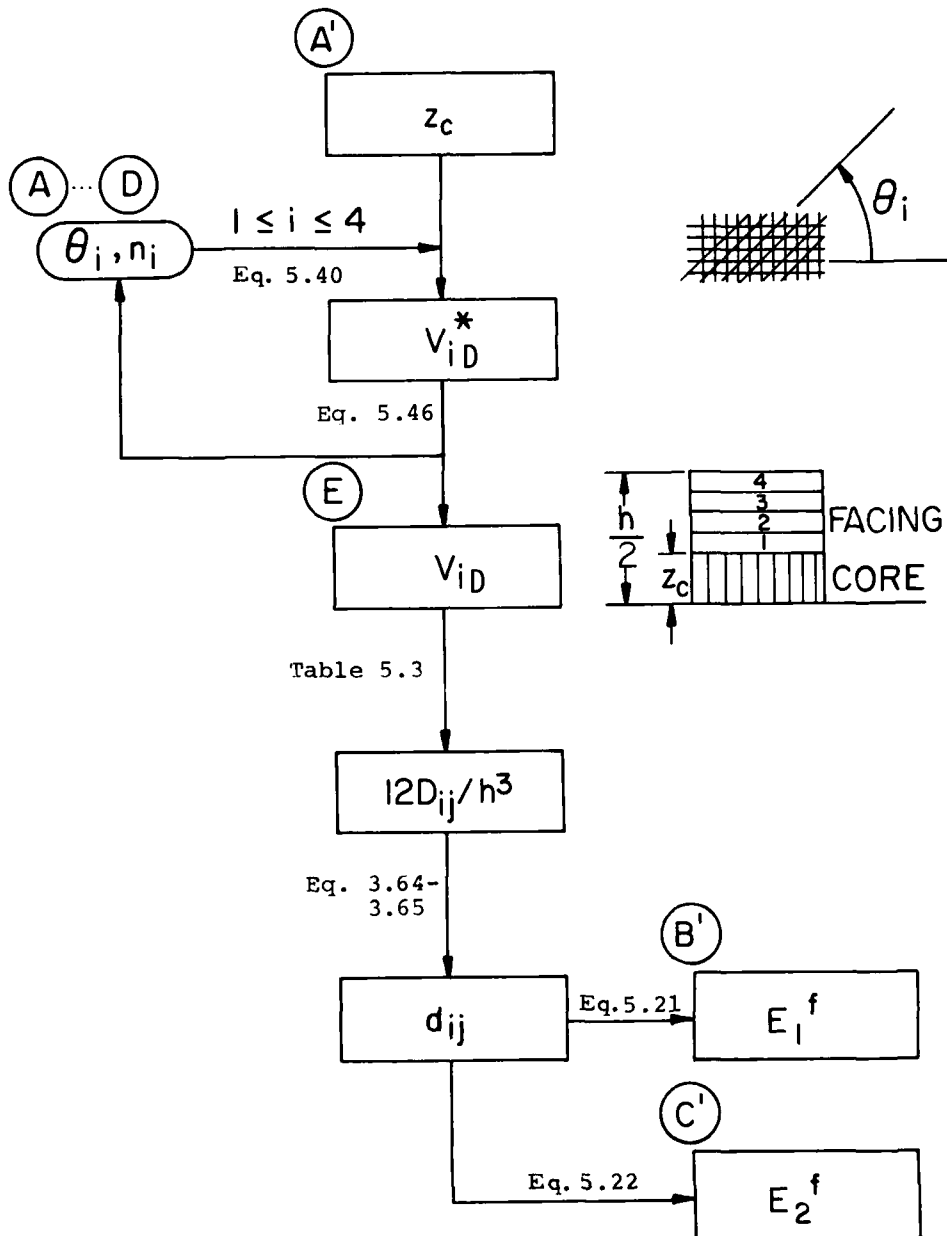
$\Delta T = -150^\circ C$
 $\epsilon = .005$

0
0

$-150^\circ C$
 $.005$

0
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 ϵ_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 for computation of $V_{1D}^*, V_{2D}^*, V_{3D}^*$ and V_{4D}^* are initialized. The thickness of the laminate up to that point is displayed:-	-- -- --	A B C D	$2 z_1$ $2 z_2$ $2 z_3$ $2 z_4$
3	Calculate V_{iD} , $12D_{ij}/h^3$ and d_{ij} .	--	E	1.00
4	Calculate engineering constants		B' C'	E_1^f 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, $z = -h/2$.

FLEXURAL RIGIDITY OF SYMMETRIC
SANDWICH PLATES

Tape# 6

Title _____

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	

Tape #6 Flexural Rigidity

z_i
 000 76 LBL
 001 15 R
 002 42 STD
 003 23 14
 004 33 +
 005 43 RCL
 006 15 14
 007 33 R
 008 43 RCL
 009 15 41
 010 33 RCL
 011 43 RCL
 012 15 14
 013 33 RCL
 014 43 RCL
 015 15 14
 016 33 RCL
 017 43 RCL
 018 15 41
 019 33 RCL
 020 43 RCL
 021 15 14
 022 33 RCL
 023 43 RCL
 024 15 14
 025 33 RCL
 026 43 RCL
 027 15 41
 028 33 RCL
 029 43 RCL
 030 15 14
 031 33 RCL
 032 43 RCL
 033 15 14
 034 33 RCL
 035 43 RCL
 036 15 41
 037 33 RCL
 038 43 RCL
 039 15 14
 040 33 RCL
 041 43 RCL
 042 15 14
 043 33 RCL
 044 43 RCL
 045 15 14
 046 33 RCL
 047 43 RCL
 048 15 14
 049 33 RCL
 050 43 RCL
 051 15 14
 052 33 RCL
 053 43 RCL
 054 15 14
 055 33 RCL
 056 43 RCL
 057 15 14
 058 33 RCL
 059 43 RCL
 060 15 14
 061 33 RCL
 062 43 RCL
 063 15 14
 064 33 RCL
 065 43 RCL
 066 15 14
 067 33 RCL
 068 43 RCL
 069 15 14
 070 33 RCL
 071 43 RCL
 072 15 14
 073 33 RCL
 074 43 RCL
 075 15 14
 076 33 RCL
 077 43 RCL
 078 15 14
 079 33 RCL

z_3
 080 14 14
 081 45 Y
 082 33 RCL
 083 43 RCL
 084 15 14
 085 33 RCL
 086 43 RCL
 087 15 14
 088 33 RCL
 089 43 RCL
 090 15 14
 091 33 RCL
 092 43 RCL
 093 15 14
 094 33 RCL
 095 43 RCL
 096 15 14
 097 33 RCL
 098 43 RCL
 099 15 14
 100 33 RCL
 101 43 RCL
 102 15 14
 103 33 RCL
 104 43 RCL
 105 15 14
 106 33 RCL
 107 43 RCL
 108 15 14
 109 33 RCL
 110 43 RCL
 111 15 14
 112 33 RCL
 113 43 RCL
 114 15 14
 115 33 RCL
 116 43 RCL
 117 15 14
 118 33 RCL
 119 43 RCL
 120 15 14
 121 33 RCL
 122 43 RCL
 123 15 14
 124 33 RCL
 125 43 RCL
 126 15 14
 127 33 RCL
 128 43 RCL
 129 15 14
 130 33 RCL
 131 43 RCL
 132 15 14
 133 33 RCL
 134 43 RCL
 135 15 14
 136 33 RCL
 137 43 RCL
 138 15 14
 139 33 RCL
 140 43 RCL
 141 15 14
 142 33 RCL
 143 43 RCL
 144 15 14
 145 33 RCL
 146 43 RCL
 147 15 14
 148 33 RCL
 149 43 RCL
 150 15 14
 151 33 RCL
 152 43 RCL
 153 15 14
 154 33 RCL
 155 43 RCL
 156 15 14
 157 33 RCL
 158 43 RCL
 159 15 14

V_{ip}
 160 50 50
 161 95 =
 162 44 SUM
 163 23 14
 164 33 RCL
 165 43 RCL
 166 15 14
 167 33 RCL
 168 43 RCL
 169 15 14
 170 33 RCL
 171 43 RCL
 172 15 14
 173 33 RCL
 174 43 RCL
 175 15 14
 176 33 RCL
 177 43 RCL
 178 15 14
 179 33 RCL
 180 43 RCL
 181 15 14
 182 33 RCL
 183 43 RCL
 184 15 14
 185 33 RCL
 186 43 RCL
 187 15 14
 188 33 RCL
 189 43 RCL
 190 15 14
 191 33 RCL
 192 43 RCL
 193 15 14
 194 33 RCL
 195 43 RCL
 196 15 14
 197 33 RCL
 198 43 RCL
 199 15 14
 200 33 RCL
 201 43 RCL
 202 15 14
 203 33 RCL
 204 43 RCL
 205 15 14
 206 33 RCL
 207 43 RCL
 208 15 14
 209 33 RCL
 210 43 RCL
 211 15 14
 212 33 RCL
 213 43 RCL
 214 15 14
 215 33 RCL
 216 43 RCL
 217 15 14
 218 33 RCL
 219 43 RCL
 220 15 14
 221 33 RCL
 222 43 RCL
 223 15 14
 224 33 RCL
 225 43 RCL
 226 15 14
 227 33 RCL
 228 43 RCL
 229 15 14
 230 33 RCL
 231 43 RCL
 232 15 14
 233 33 RCL
 234 43 RCL
 235 15 14
 236 33 RCL
 237 43 RCL
 238 15 14
 239 33 RCL

Tape #6 Flexural Rigidity

240 44 44
241 95 =
242 42 STD
243 28 28
244 43 RCL
245 42 42
246 75 -
247 43 RCL
248 43 43
249 95 =
250 65 X
251 43 RCL
252 46 46
253 75 -
254 43 RCL
255 23 23
256 65 X
257 43 RCL
258 45 45
259 95 =
260 42 STD
261 29 29
262 75 -
263 43 RCL
264 42 42
265 65 X
266 43 RCL
267 46 46
268 85 +
269 02 2
270 65 X
271 43 RCL
272 43 43
273 65 X
274 43 RCL
275 46 46
276 95 =
277 42 STD
278 30 30
279 43 RCL
280 24 24
281 65 X
282 43 RCL
283 44 44
284 55 +
285 02 2
286 85 +
287 43 RCL
288 25 25
289 65 X
290 43 RCL
291 45 45
292 95 =
293 94 +/-
294 42 STD
295 31 31
296 85 +
297 02 2
298 65 X
299 43 RCL
300 25 25
301 65 X
302 43 RCL
303 45 45
304 95 =
305 42 STD
306 22 22
307 43 RCL
308 27 27
309 65 X
310 43 RCL
311 28 28
312 65 X
313 43 RCL
314 30 30
315 85 +
316 43 RCL
317 29 29
318 65 X
319 43 RCL

IDI

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

d_{ij}*

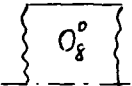
400 43 RCL
401 31 31
402 65 X
403 43 RCL
404 32 32
405 75 -
406 43 RCL
407 29 29
408 65 X
409 43 RCL
410 30 30
411 95 =
412 42 STD
413 35 35
414 43 RCL
415 29 29
416 65 X
417 43 RCL
418 31 31
419 75 -
420 43 RCL
421 27 27
422 65 X
423 43 RCL
424 32 32
425 95 =
426 42 STD
427 23 23
428 43 RCL
429 51 51
430 45 X
431 03 3
432 65 X
433 02 2
434 55 -
435 03 3
436 95 =
437 42 STD
438 51 51
439 65 X
440 43 RCL
441 39 39
442 95 =
443 35 1 X
444 49 FRD
445 33 33
446 49 FRD
447 34 34
448 49 FRD
449 35 35
450 49 FRD
451 36 36
452 49 FRD
453 37 37
454 49 FRD
455 38 38
456 01 1
457 95 =
458 91 P S
459 76 LBL
460 17 B
461 43 RCL
462 33 33
463 65 X
464 43 RCL
465 51 51
466 95 =
467 35 1 X
468 91 P S
469 76 LBL
470 18 C
471 43 RCL
472 34 34
473 65 X
474 43 RCL
475 51 51
476 95 =
477 35 1 X
478 91 P S
479 00 0

d_{ij}

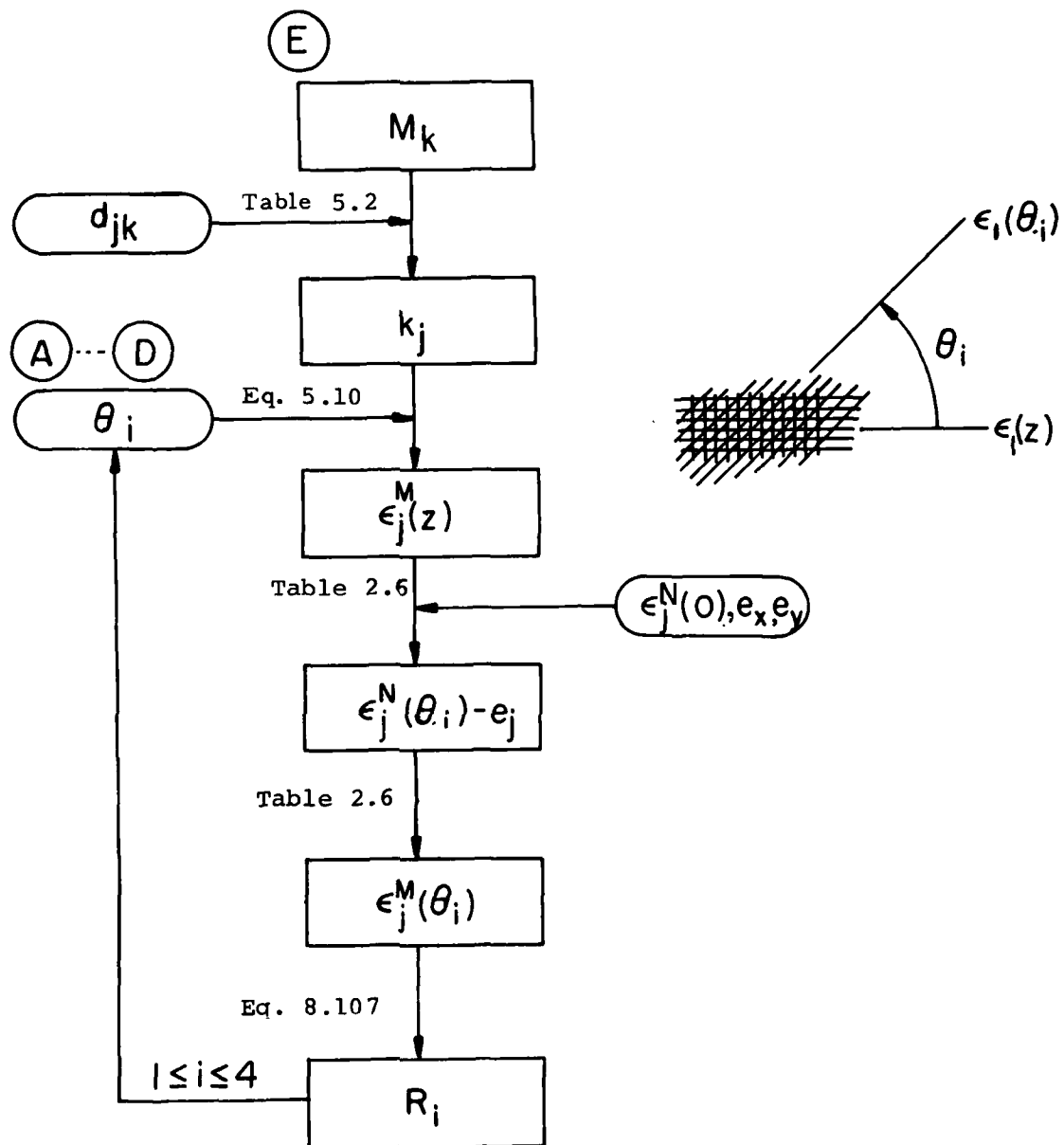
E₁

E₂

Tape #6 Flexural Rigidity / Sample Problems

	0. 00	0. 00	0. 00	0. 00	00
	181.81114 09	181.81114 09	181.81114 04	181.81114 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. 00	0. 00	0. 00	0. 00	06
	0. 00	0. 00	0. 00	0. 00	07
	0. 00	0. 00	0. 00	0. 00	08
	0. 00	0. 00	0. 00	0. 00	09
$[0_s]_s$	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
$q_1 z_1$	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 02	$q_2 z_2$ 1. -03	1. -03	16
	68. 06	68. 06	68. 06	68. 06	17
	2.8354135 03	22.65575 06	2.835426 03	22.625 06	18
	10.3 09	10.3 09	10.3 09	10.3 09	19
	5.6677823 03	22.65575 06	5.654251 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
	181.81114 09	159.00475 09	160.31502 09	108.18108 09	27
	10.346159 09	9.0528034 09	31.774281 09	59.956555 09	28
	2.8969244 09	2.5348089 09	2.8969244 09	2.5348089 09	29
$\frac{12D_{ij}}{h^3}$	0. 00	6.27375 09	0. 00	6.27375 09	30
	0. 00	0. 00	0. 00	0. 00	31
	0. 00	0. 00	0. 00	0. 00	32
	6.381220 -03	9.4711918 -03	9.2684286 -03	13.87939 -03	33
	145.60107 -03	166.48551 -03	47.278412 -03	25.042923 -03	34
	-2.320442 -03	-2.6511137 -03	-853.49478 -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
	13.424334 30	0.4994971 30	36.483150 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
$1 - (\frac{z}{h})^3$	19.710431 09	19.710431 09	19.710431 09	19.710431 09	45
	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. These strength-strain ratios are based on mechanical strains, not the total strains.	--	A	R_1
		--	B	R_2
		--	C	R_3
		--	D	R_4

FLEXURAL STRENGTH OF SYMMETRIC
SANDWICH PLATES

Tape# 7

Title _____

A'	B'	C'	D'	E'
A _{R₁}	B _{R₂}	C _{R₃}	D _{R₄}	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 $\dots R'_i$	54 G_{xx}	
10 e_1^N	25	40 $\dots R_i$	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	STD
	003	01	01
	004	91	R/S
	005	42	STD
	006	02	02
	007	91	R/S
	008	42	STD
k_j	009	03	03
	010	65	x
	011	43	RCL
	012	37	37
	013	85	+
	014	43	RCL
	015	01	01
	016	65	x
	017	43	RCL
	018	33	33
	019	85	+
	020	43	RCL
	021	02	02
	022	65	x
	023	43	RCL
	024	35	35
	025	95	=
	026	42	STD
	027	04	04
	028	43	RCL
	029	01	01
	030	65	x
	031	43	RCL
	032	35	35
	033	85	+
	034	43	RCL
	035	02	02
	036	65	x
	037	43	RCL
	038	34	34
	039	85	+
	040	43	RCL
	041	03	03
	042	65	x
	043	43	RCL
	044	38	38
	045	95	=
	046	42	STD
	047	05	05
	048	43	RCL
	049	01	01
	050	65	x
	051	43	RCL
	052	37	37
	053	85	+
	054	43	RCL
	055	02	02
	056	65	x
	057	43	RCL
	058	38	38
	059	85	+
	060	43	RCL
	061	03	03
	062	65	x
	063	43	RCL
	064	36	36
	065	95	=
	066	42	STD
	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	STD
	076	50	50
	077	43	RCL
	078	14	14
	079	71	SBR

R_2	080	35	1/X
	081	42	STD
	082	47	47
	083	43	RCL
	084	40	40
	085	42	STD
	086	42	42
	087	91	R/S
	088	76	LBL
	089	12	E
	090	43	RCL
	091	15	15
	092	42	STD
	093	50	50
	094	43	RCL
	095	16	16
	096	71	SBR
	097	35	1/X
R_3	098	42	STD
	099	48	48
	100	43	RCL
	101	40	40
	102	42	STD
	103	43	43
	104	91	R/S
	105	76	LBL
	106	13	C
	107	43	RCL
	108	17	17
	109	42	STD
	110	50	50
	111	43	RCL
	112	18	18
	113	71	SBR
	114	35	1/X
	115	42	STD
R_4	116	49	49
	117	43	RCL
	118	40	40
	119	42	STD
	120	44	44
	121	91	R/S
	122	76	LBL
	123	14	D
	124	43	RCL
	125	19	19
	126	42	STD
	127	50	50
	128	43	RCL
	129	20	20
	130	71	SBR
	131	35	1/X
	132	42	STD
	133	50	50
$\epsilon_j^M(\theta_j)$	134	43	RCL
	135	40	40
	136	42	STD
	137	45	45
	138	91	R/S
	139	76	LBL
	140	35	1/X
	141	42	STD
	142	40	40
	143	65	x
	144	43	RCL
	145	04	04
	146	95	=
	147	42	STD
	148	07	07
	149	01	1
	150	09	9
	151	66	PAU
	152	43	RCL
	153	40	40
	154	65	x
	155	43	RCL
	156	05	05
	157	95	=
	158	42	STD
	159	08	08

$\epsilon_j^N(\theta_j)$	160	43	RCL
	161	40	40
	162	65	x
	163	43	RCL
	164	06	06
	165	95	=
	166	42	STD
	167	09	09
	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	STD
	181	39	39
	182	75	-
	183	43	RCL
	184	11	11
	185	95	=
	186	42	STD
	187	40	40
	188	65	x
	189	43	RCL
	190	50	50
	191	39	CDS
	192	85	+
	193	43	RCL
	194	39	39
	195	85	+
	196	43	RCL
	197	12	12
	198	65	x
	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	STD
	209	30	30
	210	75	-
	211	02	2
	212	65	x
	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	STD
	224	31	31
	225	43	RCL
	226	12	12
	227	65	x
	228	43	RCL
	229	50	50
	230	39	CDS
	231	75	-
	232	43	RCL
	233	40	40
	234	65	x
	235	02	2
	236	65	x
	237	43	RCL
	238	50	50
	239	38	SIN

Tape #7 Flexural Strength

240	95	=
241	42	STD
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	STD
253	39	39
254	75	-
255	43	RCL
256	08	08
257	95	=
258	42	STD
259	40	40
260	65	X
261	43	RCL
262	50	50
263	39	ODS
264	85	+
265	43	RCL
266	39	39
267	85	+
268	43	RCL
269	09	09
270	65	X
271	43	RCL
272	50	50
273	28	SIN
274	55	-
275	02	2
276	95	=
277	42	STD
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	STD
288	28	28
289	43	RCL
290	09	09
291	65	X
292	43	RCL
293	50	50
294	39	ODS
295	75	-
296	43	RCL
297	40	40
298	65	X
299	02	2
300	65	X
301	43	RCL
302	50	50
303	38	SIN
304	95	=
305	42	STD
306	29	29
307	33	33
308	65	X
309	43	RCL
310	57	57
311	85	+
312	43	RCL
313	54	54
314	65	X
315	43	RCL
316	27	27
317	33	33
318	85	+
319	02	2

R_i

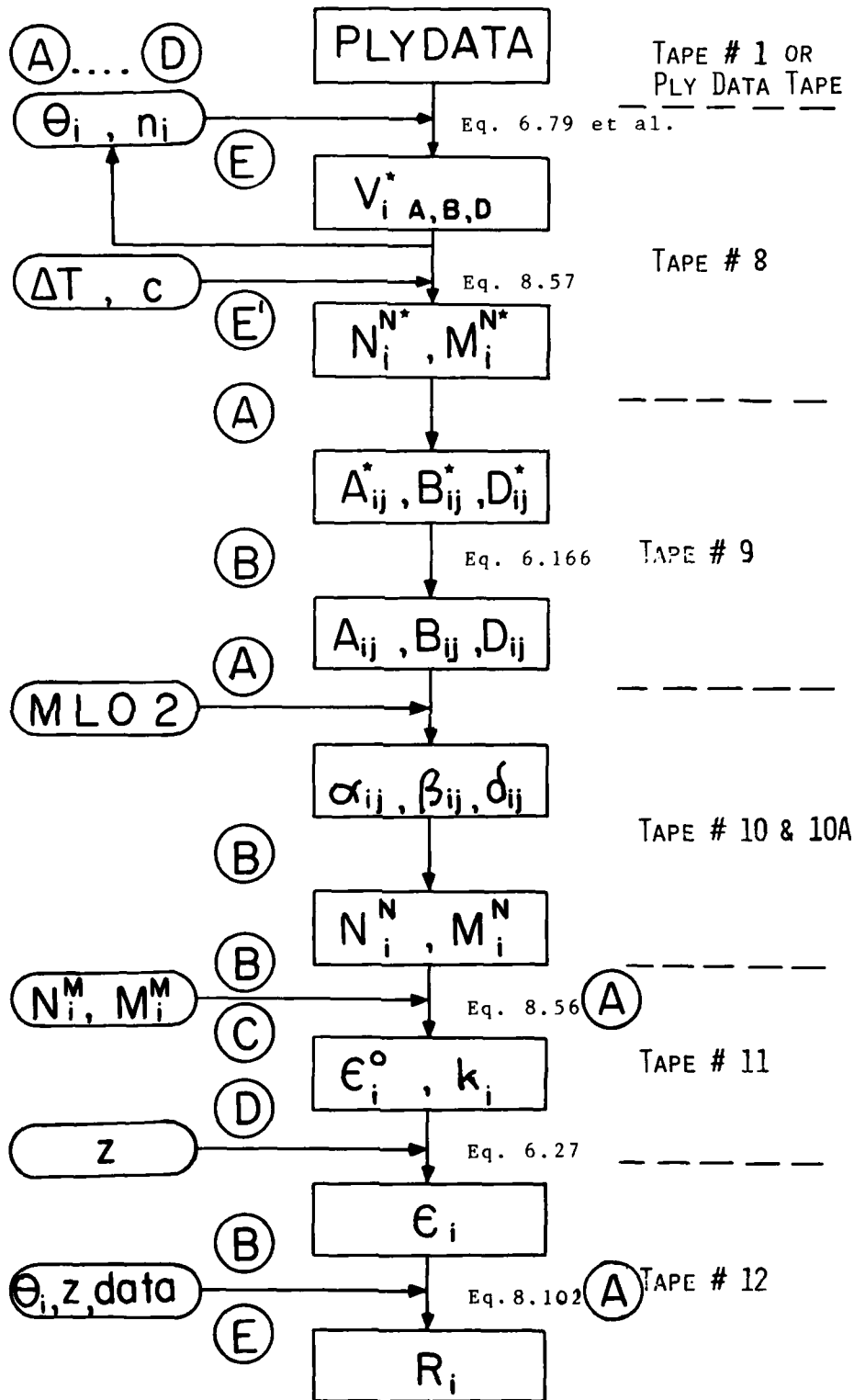
320	65	X
321	43	RCL
322	56	56
323	65	X
324	43	RCL
325	27	27
326	65	X
327	43	RCL
328	28	28
329	85	+
330	43	RCL
331	55	55
332	65	X
333	43	RCL
334	28	28
335	33	33
336	95	=
337	42	STD
338	39	39
339	43	RCL
340	58	58
341	65	X
342	43	RCL
343	27	27
344	85	+
345	43	RCL
346	59	59
347	65	X
348	43	RCL
349	28	28
350	85	+
351	02	2
352	65	X
353	53	53
354	43	RCL
355	54	54
356	65	X
357	43	RCL
358	27	27
359	65	X
360	43	RCL
361	30	30
362	85	+
363	43	RCL
364	56	56
365	65	X
366	53	53
367	43	RCL
368	27	27
369	65	X
370	43	RCL
371	31	31
372	85	+
373	43	RCL
374	28	28
375	65	X
376	43	RCL
377	30	30
378	54	54
379	85	+
380	43	RCL
381	55	55
382	65	X
383	43	RCL
384	28	28
385	65	X
386	43	RCL
387	31	31
388	85	+
389	43	RCL
390	57	57
391	65	X
392	43	RCL
393	29	29
394	65	X
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	STD
405	40	40
406	01	1
407	75	-
408	43	RCL
409	54	54
410	65	X
411	43	RCL
412	30	30
413	33	33
414	75	-
415	02	2
416	65	X
417	43	RCL
418	56	56
419	65	X
420	43	RCL
421	30	30
422	65	X
423	43	RCL
424	31	31
425	75	-
426	43	RCL
427	55	55
428	65	X
429	43	RCL
430	31	31
431	33	33
432	75	-
433	43	RCL
434	57	57
435	65	X
436	43	RCL
437	32	32
438	33	33
439	75	-
440	43	RCL
441	58	58
442	65	X
443	43	RCL
444	30	30
445	75	-
446	43	RCL
447	59	59
448	65	X
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	33
459	95	=
460	34	34
461	42	STD
462	39	39
463	75	-
464	43	RCL
465	40	40
466	95	=
467	42	STD
468	40	40
469	75	-
470	02	2
471	65	X
472	43	RCL
473	39	39
474	95	=
475	94	+/-
476	92	RTN
477	00	0
478	00	0
479	00	0

Tape #7 Flexural Strength / Sample Problems

M_k	0. 00	0. 00	0. 00	0. 00	00
	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	13.87939-03	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	13.87939-06	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
	5.6617823 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	13.87939-06	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	13.87939-03	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	874.19028 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	47.6092482 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**	$(-\frac{n}{2}+n_1+\dots)$
		.	.	.
		.	.	.
		.	.	.
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.

THE V'S AND NONMECHANICAL FORCES
OF GENERAL LAMINATES

Tape# 8 Title _____

A'	B'	C'	D'	E' $\Delta T, c$
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 v_x	35 V_{1B}^*	50 $4\theta_i$	
06 θ_4	21 E_s	36 V_{2B}^*	51 N_1^{N*}	
07 $n_4, \Delta T$	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	PCL	160	06	06
	001	11	H	081	17	17	161	71	SEP
	002	57	ENG	082	45	X ²	162	33	X ²
	003	42	STD	083	03	3	163	76	LBL
	004	26	26	084	95	=	164	89	n
	005	99	PRT	085	35	1 1/2	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	FRD	169	11	11
	010	42	STD	090	16	16	170	95	=
	011	46	46	091	71	SEP	171	42	STD
	012	42	STD	092	89	n	172	12	12
	013	11	11	093	43	PCL	173	43	PCL
	014	00	0	094	00	00	174	10	10
	015	49	FRD	095	71	SEP	175	33	X ²
	016	47	47	096	33	X ²	176	75	-
	017	49	FRD	097	91	R/S	177	43	PCL
θ_1, n_1	018	45	48	098	76	LBL	178	11	11
	019	49	FRD	099	12	B	179	33	X ²
	020	31	31	100	42	STD	180	95	=
	021	49	FRD	101	02	02	181	42	STD
	022	32	32	102	99	PRT	182	13	13
	023	49	FRD	103	43	RCL	183	43	PCL
	024	33	33	104	10	10	184	10	10
	025	49	FRD	105	42	STD	185	33	X ²
	026	34	34	106	11	11	186	65	X
	027	49	FRD	107	91	R/S	187	43	RCL
	028	35	35	108	42	STD	188	10	10
	029	49	FRD	109	03	03	189	75	-
	030	36	36	110	99	PRT	190	53	-
	031	49	FRD	111	44	SUM	191	43	RCL
	032	37	37	112	10	10	192	11	11
	033	49	FRD	113	71	SEP	193	33	X ²
	034	38	38	114	89	n	194	65	X
	035	49	FRD	115	43	RCL	195	43	RCL
	036	39	39	116	02	02	196	11	11
	037	49	FRD	117	71	SEP	197	54	-
	038	40	40	118	33	X ²	198	95	=
	039	91	R/S	119	91	R/S	199	42	STD
θ_1, n_1	040	99	PRT	120	76	LBL	200	14	14
	041	42	STD	121	13	C	201	92	RTN
	042	00	00	122	42	STD	202	76	LBL
	043	91	R/S	123	04	04	203	33	X ²
	044	99	PRT	124	99	PRT	204	65	X
	045	42	STD	125	43	PCL	205	02	2
	046	01	01	126	10	10	206	95	=
	047	85	+	127	42	STD	207	42	STD
	048	43	RCL	128	11	11	208	49	49
	049	46	46	129	91	R/S	209	65	X
	050	95	=	130	42	STD	210	02	2
	051	42	STD	131	05	05	211	95	=
	052	10	10	132	99	PRT	212	42	STD
	053	43	RCL	133	44	SUM	213	50	50
	054	41	41	134	10	10	214	43	RCL
	055	42	STD	135	71	SEP	215	49	49
	056	09	09	136	89	n	216	39	ODS
	057	33	X ²	137	43	RCL	217	65	X
	058	42	STD	138	04	04	218	43	RCL
	059	15	15	139	71	SEP	219	12	12
	060	65	-	140	33	X ²	220	95	=
	061	43	RCL	141	91	R/S	221	44	SUM
θ_1, n_1	062	41	41	142	76	LBL	222	31	31
	063	95	=	143	14	D	223	43	RCL
	064	42	STD	144	42	STD	224	50	50
	065	16	16	145	06	06	225	39	ODS
	066	43	RCL	146	99	PRT	226	65	X
	067	41	41	147	43	RCL	227	43	RCL
	068	65	-	148	10	10	228	12	12
	069	43	PCL	149	42	STD	229	95	=
	070	26	26	150	11	11	230	44	SUM
	071	95	=	151	91	R/S	231	32	32
	072	42	STD	152	42	STD	232	43	RCL
	073	17	17	153	07	07	233	49	49
	074	35	1 1/2	154	99	PRT	234	38	SIN
	075	49	FRD	155	44	SUM	235	65	X
	076	09	09	156	10	10	236	43	RCL
	077	33	X ²	157	71	SEP	237	12	12
	078	49	FRD	158	89	n	238	95	=
	079	15	15	159	43	RCL	239	44	SUM

```

239 44 SUM
240 33 33
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_{iABD}

```

320 44 SUM
321 48 48
322 93 RTH
323 75 LEL
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 31 E
356 76 LEL
357 10 E
358 42 STD
359 07 07
360 99 PRT
361 91 R/S
362 42 STD
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 STD
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 STD
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_{iN}
 M_{iN}

```

400 95 =
401 42 STD
402 11 10
403 43 RCL
404 37 37
405 65 *
406 43 RCL
407 39 39
408 85 +
409 43 RCL
410 38 38
411 65 *
412 43 RCL
413 28 28
414 95 =
415 42 STD
416 11 11
417 85 +
418 43 RCL
419 10 10
420 95 =
421 55 -
422 02 2
423 95 =
424 42 STD
425 10 10
426 75 -
427 43 RCL
428 11 11
429 95 =
430 42 STD
431 11 11
432 65 *
433 43 RCL
434 31 31
435 85 +
436 43 RCL
437 10 10
438 95 =
439 42 STD
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 STD
451 52 52
452 43 RCL
453 33 33
454 65 *
455 43 RCL
456 11 11
457 95 =
458 42 STD
459 53 53
460 43 RCL
461 11 11
462 65 *
463 43 RCL
464 37 35
465 95 =
466 42 STD
467 54 54
468 94 + -
469 42 STD
470 55 55
471 43 RCL
472 11 11
473 65 *
474 43 RCL
475 37 37
476 95 =
477 42 STD
478 56 56
479 91 R/S

```

TAPE #8 V's AND NONMECHANICAL/SAMPLE PROBLEMS

[+45₈ / -45₈]_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

[0₈ / 90₈]_T

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

0. 00
8. 00
90. 00
8. 00
0. 00
0. 00
90. 00
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
-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
1.16219 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 _{A[*]_{ij},B[*]_{ij},D[*]_{ij}}	B _{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	

TAPE # 9 MODULUS GENERAL LAMINATES

A_{ij}

000	72	LBL
001	11	A
002	01	1
003	02	2
004	66	FRU
005	43	RCL
006	17	17
007	42	STD
008	55	59
009	43	RCL
010	42	42
011	75	-
012	43	RCL
013	43	43
014	95	=
015	42	STD
016	09	09
017	95	+
018	02	2
019	65	X
020	43	RCL
021	42	43
022	95	=
023	42	STD
024	10	10
025	85	+
026	43	RCL
027	44	44
028	65	X
029	43	RCL
030	31	31
031	85	+
032	43	RCL
033	32	32
034	65	X
035	43	RCL
036	45	45
037	95	=
038	42	STD
039	11	11
040	75	-
041	02	2
042	65	X
043	43	RCL
044	44	44
045	65	X
046	43	RCL
047	31	31
048	95	=
049	42	STD
050	12	12
051	43	RCL
052	09	09
053	75	-
054	43	RCL
055	45	45
056	65	X
057	43	RCL
058	32	32
059	95	=
060	42	STD
061	13	13
062	75	-
063	43	RCL
064	42	42
065	85	+
066	02	2
067	65	X
068	43	RCL
069	43	43
070	95	=
071	42	STD
072	14	14
073	43	RCL
074	33	33
075	65	X
076	43	RCL
077	44	44
078	55	-
079	02	2

080	95	+
081	43	RCL
082	34	34
083	65	X
084	43	RCL
085	45	45
086	95	=
087	42	STD
088	15	15
089	75	-
090	02	2
091	65	X
092	43	RCL
093	45	45
094	65	X
095	43	RCL
096	34	34
097	95	=
098	42	STD
099	16	16

B_{ij}

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

D_{ij}

160	95	=
161	43	STD
162	23	23
163	43	RCL
164	10	10
165	85	+
166	43	RCL
167	44	44
168	65	X
169	43	RCL
170	39	39
171	85	+
172	43	RCL
173	45	45
174	65	X
175	43	RCL
176	40	40
177	95	=
178	42	STD
179	23	23
180	75	-
181	02	2
182	65	X
183	43	RCL
184	44	44
185	65	X
186	43	RCL
187	39	39
188	95	=
189	42	STD
190	24	24
191	43	RCL
192	09	09
193	75	-
194	43	RCL
195	45	45
196	65	X
197	43	RCL
198	40	40
199	95	=
200	42	STD
201	25	25
202	75	-
203	43	RCL
204	42	42
205	85	+
206	02	2
207	65	X
208	43	RCL
209	43	43
210	95	=
211	42	STD
212	26	26
213	43	RCL
214	44	44
215	65	X
216	43	RCL
217	47	47
218	55	-
219	02	2
220	85	+
221	43	RCL
222	45	45
223	65	X
224	43	RCL
225	48	48
226	95	=
227	42	STD
228	27	27
229	75	-
230	02	2
231	65	X
232	43	RCL
233	45	45
234	65	X
235	43	RCL
236	48	48
237	95	=
238	42	STD
239	28	28

A_{ij}

240	91	F 3
241	8	LBL
242	13	E
243	43	RCL
244	53	59
245	43	FRD
246	11	11
247	43	FRD
248	12	12
249	43	FRD
250	13	13
251	43	FRD
252	14	14
253	43	FRD
254	15	15
255	43	FRD
256	16	16

B_{ij}

257	33	33
258	55	-
259	02	2
260	95	=
261	43	FRD
262	17	17
263	43	FRD
264	18	18
265	43	FRD
266	19	19
267	43	FRD
268	20	20
269	43	FRD
270	21	21
271	43	FRD
272	22	22

D_{ij}

273	65	X
274	43	RCL
275	53	59
276	55	-
277	06	6
278	95	=
279	43	FRD
280	23	23
281	43	FRD
282	24	24
283	43	FRD
284	25	25
285	43	FRD
286	26	26
287	43	FRD
288	27	27
289	43	FRD
290	28	28
291	00	0
292	00	0
293	33	INV
294	30	LST
295	91	F 3
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

TAPE #9 MODULUS/SAMPLE PROBLEMS

	0.	00		0.	00
	0.	01		0.	01
	-45.	02		40.	02
	8.	03		0.	03
	0. 00	04		0. 00	04
	0. 00	05		0. 00	05
	-45. 00	06		90. 00	06
	-150. 00	07		-150. 00	07
	5. -03	08		5. -03	08
	22.607356	09		22.607356	09
	76.368218	10		76.368218	10
	113.31557	11		192.1573	11
	113.31557	12		192.1573	12
A _{ij}	84.635573	13		5.7938489	13
	93.181724	14		14.34	14
	0. 00	15		0. 00	15
	0. 00	16		0. 00	16
	0. 00	17		-85.73249	17
	0. 00	18		85.73249	18
	0. 00	19		0. 00	19
B _{ij}	0. 00	20		0. 00	20
	-42.866245	21		0. 00	21
	-42.866245	22		0. 00	22
	37.771858	23		64.052433	23
	37.771858	24		64.052433	24
	28.211858	25		1.931283	25
D _{ij}	31.060575	26		4.78	26
	0. 00	27		0. 00	27
	0. 00	28		0. 00	28
	2.8969244	29		2.8969244	29
	7.17	30		7.17	30
	0. 00	31		0. 00	31
	-1. 00	32		1. 00	32
	0. 00	33		0. 00	33
	0. 00	34		0. 00	34
	0. 00	35		-500. -03	35
	0. 00	36		0. 00	36
	-500. -03	37		0. 00	37
	0. 00	38		0. 00	38
	0. 00	39		0. 00	39
	-1. 00	40		1. 00	40
	125. -06	41		125. -06	41
	49.487787	42		49.487787	42
	26.880431	43		26.880431	43
	85.73249	44		85.73249	44
	19.710431	45		19.710431	45
	-8. 00	46		-8. 00	46
	0. 00	47		0. 00	47
	0. 00	48		0. 00	48
	-90. 00	49		180. 00	49
	-180. 00	50		360. 00	50
	7.3107032	51		7.3107032	51
	7.3107032	52		7.3107032	52
	0. 00	53		0. 00	53
	0. 00	54		2.16219	54
	0. 00	55		-2.16219	55
	2.16219	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

USER INSTRUCTIONS

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	

TAPE # 10 COMPLIANCE GENERAL LAMINATES

Data
Rearray

001	76	LBL
001	11	A
002	03	2
003	00	3
004	00	0
005	66	FRU
006	43	PCL
007	11	11
008	43	STO
009	08	08
010	43	PCL
011	13	13
012	42	STO
013	09	09
014	40	PCL
015	15	15
016	43	STO
017	10	10
018	43	PCL
019	23	33
020	43	STO
021	39	39
022	43	PCL
023	34	34
024	42	STO
025	36	36
026	43	PCL
027	35	35
028	43	STO
029	30	30
030	42	STO
031	28	35
032	43	PCL
033	33	35
034	43	STO
035	43	PCL
036	43	PCL
037	43	PCL
038	43	PCL
039	43	PCL
040	43	PCL
041	43	PCL
042	43	PCL
043	43	PCL
044	43	PCL
045	43	PCL
046	43	PCL
047	43	PCL
048	43	PCL
049	43	PCL
050	43	PCL
051	43	PCL
052	43	PCL
053	43	PCL
054	43	PCL
055	43	PCL
056	43	PCL
057	43	PCL
058	43	PCL
059	43	PCL
060	43	PCL
061	43	PCL
062	43	PCL
063	43	PCL
064	43	PCL
065	43	PCL
066	43	PCL
067	43	PCL
068	43	PCL
069	43	PCL
070	43	PCL
071	43	PCL
072	43	PCL
073	43	PCL
074	43	PCL
075	43	PCL
076	43	PCL
077	43	PCL
078	43	PCL
079	43	PCL

Inversion

080	42	STO
081	40	40
082	42	STO
083	25	25
084	43	PCL
085	18	18
086	42	STO
087	33	33
088	43	PCL
089	22	22
090	42	STO
091	19	19
092	42	STO
093	24	24
094	42	STO
095	34	34
096	42	STO
097	39	39
098	43	PCL
099	14	14
100	42	STO
101	22	22
102	43	PCL
103	10	10
104	42	STO
105	20	20
106	43	PCL
107	16	16
108	42	STO
109	21	21
110	43	PCL
111	09	09
112	42	STO
113	14	14
114	00	0
115	49	FRD
116	00	00
117	49	FRD
118	01	01
119	49	FRD
120	03	03
121	49	FRD
122	03	03
123	49	FRD
124	04	04
125	49	FRD
126	05	05
127	49	FRD
128	06	06
129	49	FRD
130	07	07
131	49	FRD
132	44	44
133	49	FRD
134	45	45
135	49	FRD
136	46	46
137	49	FRD
138	47	47
139	49	FRD
140	48	48
141	49	FRD
142	49	FRD
143	49	FRD
144	50	50
145	98	ADV
146	08	6
147	36	PGM
148	02	02
149	11	A
150	01	1
151	36	PGM
152	02	02
153	12	B
154	36	PGM
155	02	02
156	13	C
157	25	CLP
158	36	PGM
159	02	02

N_A, M_A

160	17	B'
161	31	P.S
162	76	LBL
163	12	B
164	43	PCL
165	59	59
166	49	FRD
167	51	51
168	49	FRD
169	52	52
170	49	FRD
171	53	53
172	43	PCL
173	58	58
174	33	33
175	55	-
176	02	2
177	95	=
178	48	FRD
179	54	54
180	49	FRD
181	55	55
182	49	FRD
183	56	56
184	05	5
185	01	1
186	22	JNV
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	080	60	DEG	160	60	DP
001	11	A	081	02	2	161	25	25
002	01	1	082	32	XIT	162	02	DP
003	42	STD	083	42	RCL	163	26	26
004	00	00	084	49	49	164	51	STD
005	01	1	085	67	EQ	165	01	01
006	01	1	086	17	E'	166	47	47
007	00	0	087	70	GRD	167	76	LBL
008	66	PAU	088	76	LBL	168	34	FX
009	42	RCL	089	70	GRD	169	01	1
010	00	00	090	03	2	170	04	4
011	32	XIT	091	32	XIT	171	42	STD
012	13	B	092	42	RCL	172	01	01
013	69	DP	093	49	49	173	02	3
014	20	20	094	67	EQ	174	08	8
015	01	7	095	10	E'	175	42	STD
016	32	XIT	096	80	GRD	176	02	02
017	42	RCL	097	76	LBL	177	42	RCL
018	00	00	098	80	GRD	178	45	45
019	67	EQ	099	04	4	179	48	EXC
020	52	FX	100	32	XIT	180	49	49
021	00	0	101	42	RCL	181	48	EXC
022	00	0	102	49	49	182	45	45
023	00	0	103	67	EQ	183	15	E
024	76	LBL	104	15	D'	184	76	LBL
025	58	FX	105	50	IXI	185	35	1/2
026	91	FX	106	76	LBL	186	42	RCL
027	76	LBL	107	50	IXI	187	46	46
028	12	B	108	05	5	188	48	EXC
029	42	RCL	109	32	XIT	189	49	49
030	44	44	110	42	RCL	190	48	EXC
031	67	EQ	111	49	49	191	46	46
032	32	XIT	112	67	EQ	192	02	2
033	42	RCL	113	32	SIN	193	00	0
034	45	45	114	45	YX	194	42	STD
035	67	EQ	115	76	LBL	195	01	01
036	34	FX	116	45	YX	196	02	3
037	42	RCL	117	06	6	197	08	8
038	46	46	118	32	XIT	198	42	STD
039	67	EQ	119	42	RCL	199	02	02
040	35	1/2	120	49	49	200	15	E
041	42	RCL	121	67	EQ	201	76	LBL
042	47	47	122	39	ODS	202	23	LNK
043	67	EQ	123	13	C	203	42	RCL
044	23	LNK	124	76	LBL	204	47	47
045	42	RCL	125	16	A'	205	48	EXC
046	48	48	126	01	1	206	49	49
047	67	EQ	127	42	STD	207	48	EXC
048	26	LDG	128	06	06	208	47	47
049	42	RCL	129	42	RCL	209	02	2
050	49	49	130	49	49	210	06	6
051	67	EQ	131	48	EXC	211	42	STD
052	24	CE	132	44	44	212	01	01
053	12	B	133	48	EXC	213	02	3
054	76	LBL	134	49	49	214	08	8
055	32	XIT	135	03	3	215	42	STD
056	42	RCL	136	08	8	216	02	02
057	44	44	137	42	STD	217	15	E
058	48	EXC	138	04	04	218	76	LBL
059	49	49	139	08	8	219	26	LDG
060	48	EXC	140	42	STD	220	42	RCL
061	44	44	141	05	05	221	48	48
062	08	8	142	18	C'	222	48	EXC
063	42	STD	143	76	LBL	223	49	49
064	01	01	144	18	C'	224	48	EXC
065	03	3	145	07	7	225	48	48
066	08	8	146	32	XIT	226	03	3
067	42	STD	147	42	RCL	227	02	2
068	02	02	148	06	06	228	42	STD
069	15	E	149	67	EQ	229	01	01
070	76	LBL	150	00	00	230	02	3
071	13	C	151	13	13	231	08	8
072	01	1	152	72	PC*	232	42	STD
073	32	XIT	153	04	04	233	02	02
074	42	RCL	154	62	EX*	234	15	E
075	49	49	155	05	05	235	76	LBL
076	67	EQ	156	62	EX*	236	24	CE
077	16	A'	157	04	04	237	02	3
078	60	DEG	158	69	DP	238	08	8
079	76	LBL	159	24	24	239	42	STD

241 01 01
 241 03 3
 242 08 8
 243 42 STD
 244 03 03
 245 15 E
 246 76 LBL
 247 17 B'
 248 01 1
 249 42 STD
 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 43 STD
 260 04 04
 261 01 1
 262 04 4
 263 42 STD
 264 05 05
 265 18 C'
 266 76 LBL
 267 10 E'
 268 01 1
 269 43 STD
 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 43 STD
 280 04 04
 281 02 2
 282 00 0
 283 42 STD
 284 05 05
 285 18 C'
 286 76 LBL
 287 19 D'
 288 01 1
 289 42 STD
 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 STD
 300 04 04
 301 02 2
 302 06 6
 303 42 STD
 304 05 05
 305 18 C'
 306 76 LBL
 307 38 SIN
 308 01 1
 309 42 STD
 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 STD

Data
 Rearrange

320 04 04
 321 03 3
 322 02 2
 323 42 STD
 324 05 05
 325 18 C'
 326 76 LBL
 327 35 COS
 328 01 1
 329 42 STD
 330 06 06
 331 02 3
 332 06 8
 333 42 STD
 334 04 04
 335 03 3
 336 08 8
 337 42 STD
 338 05 05
 339 18 C'
 340 76 LBL
 341 15 E
 342 01 1
 343 42 STD
 344 07 07
 345 07 7
 346 02 INT
 347 43 RCL
 348 07 07
 349 67 EQ
 350 13 C
 351 76 PC+
 352 01 01
 353 63 EX+
 354 02 02
 355 63 EX+
 356 01 01
 357 69 DP
 358 21 21
 359 89 DP
 360 22 22
 361 54 DP
 362 27 27
 363 61 STD
 364 03 03
 365 47 47
 366 76 LBL
 367 14 D
 368 05 5
 369 66 PAU
 370 43 RCL
 371 08 08
 372 42 STD
 373 11 11
 374 99 PRT
 375 43 RCL
 376 15 15
 377 42 STD
 378 12 12
 379 99 PRT
 380 43 RCL
 381 09 09
 382 42 STD
 383 13 13
 384 99 PRT
 385 43 RCL
 386 22 22
 387 42 STD
 388 14 14
 389 99 PRT
 390 43 RCL
 391 10 10
 392 42 STD
 393 15 15
 394 99 PRT
 395 43 RCL
 396 16 16
 397 99 PRT
 398 96 ADV
 399 43 RCL

400 15 15
 401 42 STD
 402 17 17
 403 99 PRT
 404 43 RCL
 405 18 18
 406 99 PRT
 407 43 RCL
 408 32 32
 409 42 STD
 410 19 19
 411 99 PRT
 412 43 RCL
 413 27 27
 414 42 STD
 415 20 20
 416 99 PRT
 417 43 RCL
 418 25 25
 419 42 STD
 420 21 21
 421 99 PRT
 422 43 RCL
 423 38 38
 424 42 STD
 425 22 22
 426 99 PRT
 427 43 RCL
 428 28 28
 429 42 STD
 430 23 23
 431 99 PRT
 432 43 RCL
 433 39 39
 434 42 STD
 435 24 24
 436 99 PRT
 437 43 RCL
 438 34 34
 439 42 STD
 440 25 25
 441 99 PRT
 442 96 ADV
 443 43 RCL
 444 29 29
 445 42 STD
 446 26 26
 447 99 PRT
 448 43 RCL
 449 36 36
 450 42 STD
 451 27 27
 452 99 PRT
 453 43 RCL
 454 30 30
 455 42 STD
 456 28 28
 457 99 PRT
 458 43 RCL
 459 43 43
 460 42 STD
 461 29 29
 462 99 PRT
 463 43 RCL
 464 31 31
 465 42 STD
 466 30 30
 467 99 PRT
 468 43 RCL
 469 37 37
 470 42 STD
 471 31 31
 472 99 PRT
 473 96 ADV
 474 05 5
 475 01 1
 476 22 INV
 477 90 LST
 478 96 ADV
 479 91 R/S

TAPE #10 COMPLIANCE/SAMPLE PROBLEMS

6. 00	14.621406 03	51	6. 00	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
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
	2. -03	59		2. -03	59
23.712556-09 α_{11}			12.948013-09		
23.712556-09 α_{11}			12.948013-09		
-11.154947-09 α_{12}			-390.40323-12		
26.676832-09 α_{16}			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_{44}	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_{11}	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_{16}	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

USER INSTRUCTIONS

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 e_i^{ON}, k_i^N		A	k_6^N
2	Calculate e_i^N	z	D	e_6^N
3	Calculate $e_i^{O(N+M)}, k_i^{N+M}$	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 e_i^M	z	D	e_6^M

IN-PLANE STRAIN AND CURVATURE
OF GENERAL LAMINATES

Tape# 11

Title _____

A'	B'	C'	D'	E'
A e_i^{ON}, k_i^N	B e_i^{OM}, k_i^{OM}	C	D e_i^N, e_i^M	E
00	15 α_{16}	30 δ_{16}	45 Σe_1	
01 e_1^{ON}	16 α_{26}	31 δ_{26}	46 Σe_2	
02 e_2^{ON}	17 β_{11}	32	47 Σe_6	
03 e_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 e_1^{OM}	51 N_1^N, N_1^M	
07 e_1	22 β_{16}	37 e_2^{OM}	52 N_2^N, N_2^M	
08 e_2	23 β_{61}	38 e_6^{OM}	53 N_6^N, N_6^M	
09 e_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 e_x	
13 α_{12}	28 δ_{12}	43	58 e_y	
14 α_{66}	29 δ_{66}	44	59 h, z	

TAPE # 11 IN-PLANE STRAINS AND CURVATURE GENERAL LAMINATES

ϵ_{xx}	000	76	LBL	080	91	R/S	160	42	STD
	001	11	R	081	76	LBL	161	46	46
	002	71	BBP	082	30	NA	162	43	PCL
	003	01	NA	083	01	1	163	15	15
	004	43	PCL	084	01	1	164	65	X
	005	45	45	085	66	FRU	165	43	PCL
	006	42	STD	086	43	PCL	166	51	51
	007	01	01	087	11	11	167	85	+
	008	43	PCL	088	65	X	168	43	PCL
	009	46	46	089	43	PCL	169	16	16
	010	42	STD	090	51	51	170	65	X
	011	02	02	091	85	+	171	43	PCL
	012	43	PCL	092	43	PCL	172	52	52
	013	47	47	093	13	13	173	85	+
	014	42	STD	094	65	X	174	43	PCL
	015	03	03	095	43	PCL	175	14	14
	016	43	PCL	096	52	52	176	65	X
	017	46	46	097	85	+	177	43	PCL
	018	43	STD	098	43	PCL	178	53	53
	019	04	04	099	15	15	179	85	+
	020	43	PCL	100	65	X	180	43	PCL
	021	46	46	101	43	PCL	181	23	23
	022	42	STD	102	53	53	182	65	X
	023	05	05	103	85	+	183	43	PCL
	024	43	PCL	104	43	PCL	184	54	54
	025	50	50	105	17	17	185	85	+
	026	42	STD	106	65	X	186	43	PCL
	027	06	06	107	43	PCL	187	25	25
	028	91	R/S	108	54	54	188	65	X
ϵ_{yy}	029	76	LBL	109	85	+	189	43	PCL
	030	13	B	110	43	PCL	190	55	55
	031	42	STD	111	19	19	191	85	+
	032	51	51	112	65	X	192	43	PCL
	033	99	PRT	113	43	PCL	193	21	21
	034	91	R/S	114	55	55	194	65	X
	035	42	STD	115	85	+	195	43	PCL
	036	52	52	116	43	PCL	196	56	56
	037	99	PRT	117	22	22	197	95	=
	038	91	R/S	118	65	X	198	42	STD
	039	42	STD	119	43	PCL	199	47	47
	040	53	53	120	56	56	200	43	PCL
	041	99	PRT	121	95	=	201	17	17
	042	91	R/S	122	42	STD	202	65	X
	043	42	STD	123	45	45	203	43	PCL
	044	54	54	124	43	PCL	204	51	51
	045	99	PRT	125	13	13	205	85	+
	046	91	R/S	126	65	X	206	43	PCL
	047	42	STD	127	43	PCL	207	20	20
	048	55	55	128	51	51	208	65	X
	049	99	PRT	129	85	+	209	43	PCL
	050	91	R/S	130	43	PCL	210	52	52
	051	42	STD	131	12	12	211	85	+
	052	56	56	132	65	X	212	43	PCL
	053	99	PRT	133	43	PCL	213	23	23
	054	71	BBP	134	52	52	214	65	X
	055	33	NA	135	85	+	215	43	PCL
	056	43	PCL	136	43	PCL	216	53	53
	057	45	45	137	16	16	217	85	+
	058	42	STD	138	65	X	218	43	PCL
	059	36	36	139	43	PCL	219	36	36
	060	43	PCL	140	53	53	220	65	X
	061	46	46	141	85	+	221	43	PCL
	062	42	STD	142	43	PCL	222	54	54
	063	37	37	143	20	20	223	85	+
	064	43	PCL	144	65	X	224	43	PCL
	065	47	47	145	43	PCL	225	28	28
	066	42	STD	146	54	54	226	65	X
	067	38	38	147	85	+	227	43	PCL
	068	43	PCL	148	43	PCL	228	55	55
	069	48	48	149	18	18	229	85	+
	070	42	STD	150	65	X	230	43	PCL
	071	39	39	151	43	PCL	231	30	30
	072	43	PCL	152	55	55	232	65	X
	073	49	49	153	85	+	233	43	PCL
	074	42	STD	154	43	PCL	234	56	56
	075	40	40	155	24	24	235	95	=
	076	43	PCL	156	65	X	236	42	STD
	077	50	50	157	43	PCL	237	48	48
	078	42	STD	158	56	56	238	43	PCL
	079	41	41	159	95	=	239	19	19

340	65	-
341	43	RCL
342	51	51
343	85	+
344	43	RCL
345	18	18
346	65	X
347	43	RCL
348	52	52
349	85	+
350	43	RCL
351	25	25
352	85	X
353	43	RCL
354	53	53
355	85	+
356	43	RCL
357	28	28
358	65	X
359	43	RCL
360	54	54
361	85	+
362	43	RCL
363	27	27
364	65	X
365	43	RCL
366	55	55
367	85	+
368	43	RCL
369	31	31
370	65	X
371	43	RCL
372	56	56
373	85	+
374	43	RCL
375	49	49
376	43	RCL
377	13	13
378	65	X
379	43	RCL
380	51	51
381	85	+
382	43	RCL
383	24	24
384	65	X
385	43	RCL
386	52	52
387	85	+
388	43	RCL
389	21	21
390	65	X
391	43	RCL
392	53	53
393	85	+
394	43	RCL
395	30	30
396	65	X
397	43	RCL
398	54	54
399	85	+
400	43	RCL
401	31	31
402	65	X
403	43	RCL
404	55	55
405	85	+
406	43	RCL
407	29	29
408	65	X
409	43	RCL
410	56	56
411	95	=
412	42	STD
413	50	50
414	92	PTH
415	91	P/S
416	76	LBL
417	14	D
418	42	STD
419	59	59

62

320	65	X
321	43	RCL
322	48	48
323	85	+
324	43	RCL
325	45	45
326	95	=
327	99	PRT
328	42	STD
329	07	07
330	43	RCL
331	46	46
332	85	+
333	43	RCL
334	59	59
335	65	X
336	43	RCL
337	49	49
338	95	=
339	99	PRT
340	42	STD
341	08	08
342	43	RCL
343	47	47
344	85	+
345	43	RCL
346	59	59
347	65	X
348	43	RCL
349	50	50
350	95	=
351	42	STD
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

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

258.5539-06 ϵ_1^N
258.5539-06
852.87698-06

1.00 N_1^M
0.00 N_2^M
0.00 M_1^M
0.00 M_2^M
0.00

23.712556-09 ϵ_1^M
-11.154947-09
17.330573-09

684.99239-06
-167.88459-06
0.00

1.00
0.00
0.00
0.00
0.00

30.278586-09
-390.40323-12
0.00

0.00 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
0.00 10
23.712556-09 11
23.712556-09 12
-11.154947-09 13
26.676832-09 14
0.00 15
0.00 16
0.00 17
0.00 18
0.00 19
0.00 20
0.00 21
17.330573-06 22
17.330573-06 23
17.330573-06 24
17.330573-06 25
71.137669-03 26
71.137669-03 27
-33.464841-03 28
80.030496-03 29
0.00 30
0.00 31
0.00 32
0.00 33
17.330573-06 34
-33.464841-03 35
23.712556-09 36
-11.154947-09 37
0.00 38
0.00 39
0.00 40
17.330573-06 41
0.00 42
80.030496-03 43
1.00 44
23.712556-09 45
-11.154947-09 46
0.00 47
0.00 48
0.00 49
17.330573-06 50
1.00 51
0.00 52
0.00 53
0.00 54
0.00 55
0.00 56
-1.5-06 57
1.125-03 58
1.-03 59

0.00 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
0.00 10
12.948013-09 11
12.948013-09 12
-390.40323-12 13
69.735007-09 14
0.00 15
0.00 16
17.330573-06 17
-17.330573-06 18
-82.744711-18 19
84.9-18 20
0.00 21
0.00 22
0.00 23
0.00 24
0.00 25
38.844038-03 26
38.844038-03 27
-1.1712097-03 28
209.20502-03 29
0.00 30
0.00 31
-82.744711-18 32
-17.330573-06 33
0.00 34
-1.1712097-03 35
12.948013-09 36
-390.40323-12 37
0.00 38
17.330573-06 39
-82.744711-18 40
0.00 41
0.00 42
209.20502-03 43
1.00 44
12.948013-09 45
-390.40323-12 46
0.00 47
17.330573-06 48
-82.744711-18 49
0.00 50
1.00 51
0.00 52
0.00 53
0.00 54
0.00 55
0.00 56
-1.5-06 57
1.125-03 58
1.-03 59

USER INSTRUCTIONS

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 e_j^N, e_j^M enter distance from middle plane	z	B	e_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# 12Title 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	

TAPE # 12 STRENGTH RATIOS GENERAL LAMINATES

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

240 28 28
 241 85 +
 242 43 RCL
 243 09 09
 244 65 x
 245 43 RCL
 246 24 24
 247 38 SIN
 248 55 +
 249 02 2
 250 95 =
 251 42 STD
 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 STD
 262 33 33
 263 43 RCL
 264 09 09
 265 65 x
 266 43 RCL
 267 24 24
 268 39 CDS
 269 75 -
 270 43 RCL
 271 29 29
 272 65 x
 273 02 2
 274 65 x
 275 43 RCL
 276 24 24
 277 38 SIN
 278 95 =
 279 42 STD
 280 34 34

 281 33 X²
 282 65 x
 283 43 RCL
 284 57 57
 285 85 +
 286 43 RCL
 287 54 54
 288 65 x
 289 43 RCL
 290 32 32
 291 33 X²
 292 85 +
 293 02 2
 294 65 x
 295 43 RCL
 296 56 56
 297 65 x
 298 43 RCL
 299 32 32
 300 65 x
 301 43 RCL
 302 33 33
 303 85 +
 304 43 RCL
 305 55 55
 306 65 x
 307 43 RCL
 308 33 33
 309 33 X²
 310 95 =
 311 42 STD
 312 28 28
 313 43 RCL
 314 58 58
 315 65 x
 316 43 RCL
 317 32 32
 318 85 +
 319 43 RCL

R_i

320 59 59
 321 65 x
 322 43 RCL
 323 33 33
 324 85 +
 325 02 2
 326 65 x
 327 53 (
 328 43 RCL
 329 54 54
 330 65 x
 331 43 RCL
 332 32 32
 333 65 x
 334 43 RCL
 335 25 25
 336 85 +
 337 43 RCL
 338 56 56
 339 65 x
 340 53 (
 341 43 RCL
 342 32 32
 343 65 x
 344 43 RCL
 345 26 26
 346 85 +
 347 43 RCL
 348 33 33
 349 65 x
 350 43 RCL
 351 25 25
 352 54)
 353 85 +
 354 43 RCL
 355 55 55
 356 65 x
 357 43 RCL
 358 33 33
 359 65 x
 360 43 RCL
 361 26 26
 362 85 +
 363 43 RCL
 364 57 57
 365 65 x
 366 43 RCL
 367 34 34
 368 65 x
 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 STD
 379 29 29
 380 01 1
 381 75 -
 382 43 RCL
 383 54 54
 384 65 x
 385 43 RCL
 386 25 25
 387 33 X²
 388 75 -
 389 02 2
 390 65 x
 391 43 RCL
 392 56 56
 393 65 x
 394 43 RCL
 395 25 25
 396 65 x
 397 43 RCL
 398 26 26
 399 75 -

400 43 RCL
 401 55 55
 402 65 x
 403 43 RCL
 404 26 26
 405 33 X²
 406 75 -
 407 43 RCL
 408 57 57
 409 65 x
 410 43 RCL
 411 27 27
 412 33 X²
 413 75 -
 414 43 RCL
 415 58 58
 416 65 x
 417 43 RCL
 418 25 25
 419 75 -
 420 43 RCL
 421 59 59
 422 65 x
 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 X²
 433 95 =
 434 34 FX
 435 42 STD
 436 28 28
 437 75 -
 438 43 RCL
 439 29 29
 440 95 =
 441 42 STD
 442 22 22
 443 99 PRT
 444 75 -
 445 02 2
 446 65 x
 447 43 RCL
 448 28 28
 449 95 =
 450 94 +/-
 451 42 STD
 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

TAPE #12 STRENGTH RATIOS/SAMPLE PROBLEMS

1. -03	ϵ	1. -03	
258.5539-06	ϵ_N	684.99239-06	
258.5539-06		-167.88459-06	
852.87698-06		0. 00	
23.712556-09	ϵ_M	30.278586-09	
-11.154947-09		-390.40323-12	
17.330573-09		0. 00	
-45. 00	$\sigma(u)$	90. 00	
184.99191-03	R	143.37864-03	
368.44954-03	R	780.02778-03	

-45. 00	00	90. 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
258.5539-06	10	684.99239-06	10
258.5539-06	11	-167.88459-06	11
852.87698-06	12	0. 00	12
23.712556-09	13	12.948013-09	13
-11.154947-09	14	-390.40323-12	14
0. 00	15	0. 00	15
0. 00	16	17.330573-06	16
0. 00	17	-82.744711-18	17
17.330573-06	18	0. 00	18
-1.5-06	19	-1.5-06	19
1.125-03	20	1.125-03	20
1. -03	21	1. -03	21
184.99191-03	22	143.37864-03	22
368.44954-03	23	780.02778-03	23
-90. 00	24	180. 00	24
-166.38459-06	25	-166.38459-06	25
-440.00761-06	26	-440.00761-06	26
1.2-15	27	0. 00	27
276.72072-03	28	461.70321-03	28
184.99191-03	29	143.37864-03	29
7.17-09	30	7.17-09	30
0. 00	31	0. 00	31
-2.3864819-09	32	-390.40323-12	32
14.944091-09	33	30.278586-09	33
34.867503-09	34	0. 00	34
0. 00	35	0. 00	35
0. 00	36	0. 00	36
0. 00	37	0. 00	37
0. 00	38	0. 00	38
1.0044814-00	39	1.0044814-00	39
0. 00	40	0. 00	40
125. -06	41	125. -06	41
49.487787-09	42	49.487787-09	42
26.880431-09	43	26.880431-09	43
85.73249-09	44	85.73249-09	44
19.710431-09	45	19.710431-09	45
444.44444-21	46	444.44444-21	46
0. 00	47	0. 00	47
101.62602-18	48	101.62602-18	48
20.934959-09	49	20.934959-09	49
-500. -03	50	-500. -03	50
-3.3603243-18	51	-3.3603243-18	51
0. 00	52	0. 00	52
0. 00	53	0. 00	53
12.004384-03	54	12.004384-03	54
10.680652-03	55	10.680652-03	55
-3.0691032-03	56	-3.0691032-03	56
11.117842-03	57	11.117842-03	57
60.646995-00	58	60.646995-00	58
216.59641-00	59	216.59641-00	59