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INSTRUCTIONS FOR TI-59 COMBINED CARD/MODULE CALCULATIONS FOR IN--ETC(U)
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AFWAL-TR-81-4183

INSTRUCTIONS FOR TI-59 COMBINED CARD/MODULE CALCULATIONS FOR IN-PLANE PROPERTIES OF SYMMETRIC HYBRID LAMINATES

Stella D. Gates

MECHANICS & SURFACE INTERACTIONS BRANCH
NONMETALLIC MATERIALS DIVISION

March 1982

Final Report for Period September 1981 - November 1981

Approved for public release; distribution unlimited.

MATERIALS LABORATORY
AIR FORCE WRIGHT AERONAUTICAL LABORATORIES
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433

NOTICE

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

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AIR FORCE/56780/24 June 1982 — 500

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Composite Materials Module
Composite Materials
Properties of Unidirectional & Laminated Composites
In-Plane Stiffness & Strength
Sandwich Core Laminates
Hybrid Laminates

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

This report contains the description and instructions for the combined use of composite materials module and magnetic cards for TI-59 programmable calculators. These programs contain the key calculations of the stiffness and strength of unidirectional, and laminated hybrid composites under in-plane loading. This can include sandwich core laminates. With the combination of the module and magnetic cards, instant calculations can be made for practical use. With the use of a printer, these can be immediately outputted and recorded permanently. The formulas used in the cards and equation numbers have

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20. ABSTRACT (Cont'd)

been derived in a book entitled, "Introduction to Composite Materials", co-authored by S. W. Tsai and H. T. Hahn, published by Technomic Publishing Company, Westport, Connecticut, July 1980.

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 of Project No. 2419, "Nonmetallic Structural Material", Task No. 241903, "Composite Materials and Mechanics Technology". The time period covered by this effort was from September to November 1981. Stella D. Gates (AFWAL/MLBM) was the laboratory project engineer.

The programs are written for Texas Instruments Calculators TI-59 to operate with or without a printer. However, the use of a printer is highly recommended. The specially designed "Composite Materials Module" must be installed in place of the standard "Master Module".

This report is meant to be used in conjunction with AFWAL-TR-81-4116, "Instructions for TI-59 Combined Card/Module Calculations for In-Plane and Flexural Properties of Symmetric Laminates", co-authored by S. W. Tsai and S. D. Gates; or with a revised expanded edition currently being published. In this report, the ideas previously presented are further developed to include the case of a symmetric hybrid laminate. Some of the previous information is repeated to facilitate the operation for a user.

Any references to equations and table numbers are the same as Introduction to Composite Materials, co-authored by S. W. Tsai and H. T. Hahn, published by Technomic Publishing Company, Westport, Connecticut, in July 1980.

The author wishes to acknowledge Stephen W. Tsai of the Materials Laboratory for his encouragement and helpful suggestions.

TABLE OF CONTENTS*

* Each Combo card description includes a flow chart, user instructions, register contents, and program listing.

** Sample problems are not given in these cards. They are similar to those in the on-printer cards, Combo 1P and 4P, respectively.

NOMENCLATURE

Symbol		Definition	LABEL NAME
A_{ij}	=	in-plane modulus; i,j = 1,2,6	A
a_{ij}	=	in-plane compliance; i,j = 1,2,6	AI
A^*_{ij}	=	normalized in-plane modulus; i,j = 1,2,6	A*
a^*_{ij}	=	normalized in-plane compliance; i,j = 1,2,6	A*I
c	=	half depth of core in equivalent number of plies	CR
E_i	=	engineering constants; i = x,y,s	E
E°_i	=	effective in-plane Young's and shear moduli; i = 1,2,6	E*
F_{ij},F_i	=	strength parameters in stress space; i,j = 1,2,6	F
F^*_{xy}	=	normalized interaction term	FXY
G_{ij},G_i	=	strength parameters in strain space; i,j = 1,2,6	G
h_o	=	unit ply thickness	H
N_i	=	stress resultants; i = 1,2,6 (Prompter 6.1, 6.2, 6.6)	N
$n^{(1)}$	=	total number of plies, material 1	N1
$n^{(2)}$	=	total number of plies, material 2; or material i	N2
Q_{ij}	=	on-axis modulus; i,j = x,y,s	Q
R_t,R_t'	=	tensile and compressive strength ratios	R
S	=	shear strength	-

NOMENCLATURE

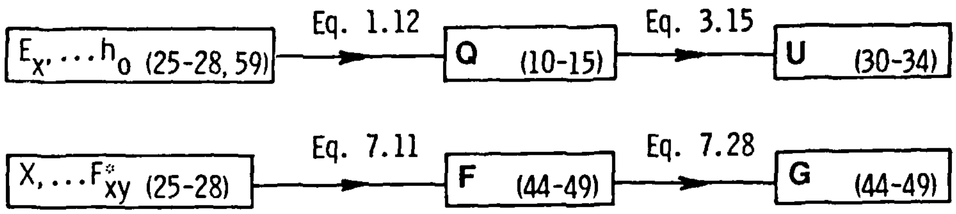
			LABEL NAME
S_{ij}	=	on-axis compliance; i,j = x,y,s	S
U_i	=	linear combinations of moduli; i = 1 to 5	-
X,X'	=	longitudinal tensile and compressive strengths	X
Y,Y'	=	transverse tensile and compressive strengths	-
ε_i^o	=	in-plane strain; i = 1,2,6	-
ν_x	=	longitudinal Poisson's ratio	-
ν_{21}^o	=	major in-plane Poisson's ratio	-
$\sigma_t^o, \sigma_t^{o'}$	=	allowable stresses, in-plane loading	Σ
Θ_t	=	ply orientation (TI 2-digit alphanumeric code = 60 as prompter)	↑

INTRODUCTION

Combos 4 and 4P are designed to allow the user to calculate the in-plane stiffness and strength of a symmetric, hybrid laminate. This laminate may be designed for two or more component materials and have a honeycomb core. The only difference between Combo 4 and 4P is the automatic print routine which occurs when Combo 4P is run while the TI-59 is attached to a printer.

A certain amount of caution must be used when working these programs because of the bookkeeping necessary when using two materials. Each material will have a different set of material properties and constants. Only one set can be kept in storage at any point in time. Therefore, it is necessary to keep track of the contents of certain data registers to maintain accuracy in calculation. More will be discussed in reference to this in the directions for each program.

AFWAL/MLBM CARD-MODULE COMBO FOR TI-59				
PLY DATA CARD			COMBO-I	P
Ex,...	X,...	SI→ENGLISH	ENGLISH→SI	



Register locations are shown in parentheses. Equation and Table numbers are those in Introduction to Composite Materials, Tsai and Hahn.

COMBO #IP PLY DATA

STEP	PROCEDURE	PRESS	PRINTER LABEL	PRINTOUT	CALCULATOR PROMPTER
1a	Initialize program	A	E	-	4
b	Enter E_x	R/S	-	E_x	3
	E_y	R/S	-	E_y	2
	ν_x	R/S	-	ν_x	1
	E_s	R/S	-	E_s	0
	h_o	R/S	H	h_o	
			Q	Q_{11}, Q_{22}, Q_{12}, Q_{66}	
			S	S_{11}, S_{22}, S_{12}, S_{66}	
			U	U_1, U_2, U_3, U_4, U_5	
			A	A_{11}, A_{22}, A_{12}, A_{66}	
			AI	a_{11}, a_{22}, a_{12}, a_{66}	a_{66}
2a	Initialize program	B	X	-	5
b	Enter X	R/S	-	X	4
	X'	R/S	-	X'	3
	Y	R/S	-	Y	2
	Y'	R/S	-	Y'	1
	S	R/S	-	S	
			FXY		0
	Enter F^*_{xy}	R/S		F^*_{xy}	
		F		F_{xx}, F_{yy}, F_{xy}, F_{ss}, F_x, F_y	
		G		G_{xx}, G_{yy}, G_{xy}, G_{ss}, G_x, G_y	G_y

COMBO #IP CONTINUED

STEP	PROCEDURE	PRESS	PRINTER LABEL	PRINTOUT	CALCULATOR PROMPTER
3	Convert SI → English	C	U'	$U'_1, U'_2, U'_3, U'_4, U'_5$	
			H'	h'_o	h'_o
4	Convert English → SI	D	U'	$U'_1, U'_2, U'_3, U'_4, U'_5$	
			H'	h'_o	h'_o

COMBO 1P PLY DATA (W/PRT) 28 JUL 81

Step	Code	Key	
000	76	LBL	
001	11	A	
002	47	CMS	
003	57	ENG	
004	58	FIX	
005	03	03	
006	01	1	
007	[illegible]	[illegible]	
008	00	0	
009	00	0	
010	42	STO	
011	02	02	
012	36	PGM	
013	11	11	
014	71	SBR	
015	90	LST	
016	04	4	
017	95	=	
018	91	R/S	Ex
019	42	STO	
020	25	25	
021	99	PRT	
022	03	3	
023	95	=	
024	91	R/S	
025	42	STO	
026	26	26	Ey
027	99	PRT	
028	02	2	
029	95	=	
030	91	R/S	
031	42	STO	Vx
032	28	28	
033	99	PRT	
034	01	1	
035	95	=	
036	91	R/S	
037	42	STO	Es
038	27	27	
039	99	PRT	
040	98	ADV	
041	00	0	
042	95	=	
043	91	R/S	
044	42	STO	ho
045	59	59	
046	02	2	
047	03	3	
048	00	0	
049	00	0	
050	42	STO	
051	02	02	
052	36	PGM	
053	11	11	
054	71	SBR	
055	90	LST	
056	43	RCL	
057	59	59	
058	99	PRT	
059	98	ADV	
060	36	PGM	
061	01	01	
062	71	SBR	
063	57	ENG	Qij
064	01	1	
065	04	4	
066	00	0	
067	00	0	
068	42	STO	
069	02	02	
070	36	PGM	
071	11	11	
072	71	SBR	
073	90	LST	
074	43	RCL	
075	10	10	
076	99	PRT	
077	43	RCL	
078	11	11	
079	99	PRT	
080	43	RCL	
081	12	12	
082	99	PRT	
083	43	RCL	
084	13	13	
085	99	PRT	
086	98	ADV	
087	36	PGM	
088	11	11	
089	71	SBR	
090	35	1/X	Sij
091	03	3	
092	06	6	
093	00	0	
094	00	0	
095	42	STO	
096	02	02	
097	36	PGM	
098	11	11	
099	71	SBR	
100	90	LST	
101	43	RCL	
102	16	16	
103	99	PRT	
104	43	RCL	
105	17	17	
106	99	PRT	
107	43	RCL	
108	18	18	
109	99	PRT	
110	43	RCL	
111	19	19	
112	99	PRT	
113	98	ADV	
114	36	PGM	
115	01	01	
116	71	SBR	Ui
117	52	EE	
118	04	4	
119	01	1	
120	00	0	
121	00	0	
122	42	STO	
123	02	02	
124	36	PGM	
125	11	11	
126	71	SBR	
127	90	LST	
128	43	RCL	
129	30	30	
130	99	PRT	
131	43	RCL	
132	31	31	
133	99	PRT	
134	43	RCL	
135	32	32	
136	99	PRT	
137	43	RCL	
138	33	33	
139	99	PRT	
140	43	RCL	
141	34	34	
142	99	PRT	
143	98	ADV	
144	01	1	
145	03	3	
146	00	0	
147	00	0	
148	42	STO	
149	02	02	
150	36	PGM	
151	11	11	
152	71	SBR	
153	90	LST	
154	43	RCL	Aij
155	10	10	
156	65	×	
157	43	RCL	
158	59	59	
159	95	=	
160	99	PRT	
161	43	RCL	
162	11	11	
163	65	×	
164	43	RCL	
165	59	59	
166	95	=	
167	99	PRT	
168	43	RCL	
169	12	12	
170	65	×	
171	43	RCL	
172	59	59	
173	95	=	
174	99	PRT	
175	43	RCL	
176	13	13	
177	65	×	
178	43	RCL	
179	59	59	
180	95	=	
181	99	PRT	
182	98	ADV	
183	01	1	
184	03	3	
185	02	2	
186	04	4	
187	42	STO	
188	02	02	
189	36	PGM	
190	11	11	
191	71	SBR	
192	90	LST	
193	43	RCL	
194	16	16	Aij
195	55	÷	
196	43	RCL	
197	59	59	
198	95	=	
199	99	PRT	
200	43	RCL	
201	17	17	
202	55	÷	
203	43	RCL	
204	59	59	
205	95	=	
206	99	PRT	
207	43	RCL	
208	18	18	
209	55	÷	
210	43	RCL	
211	59	59	
212	95	=	
213	99	PRT	
214	43	RCL	
215	19	19	
216	55	÷	
217	43	RCL	
218	59	59	
219	95	=	
220	99	PRT	
221	98	ADV	
222	91	R/S	
223	76	LBL	
224	12	B	
225	57	ENG	
226	58	FIX	
227	03	03	
228	04	4	
229	04	4	
230	00	0	
231	00	0	
232	42	STO	
233	02	02	
234	36	PGM	
235	11	11	
236	71	SBR	
237	90	LST	
238	05	5	
239	95	=	

COMBO 1P PLY DATA (W/PRT) 28 JUL 81

Program listing (annotations: X, X', y, y', S, Fxy*, Fij, Gij, SI → Engl., Engl. → SI, U_i', h_0')

```
[illegible]
35  =
    42 STD            Fxy*
    33  33
    99 PRT
    98 ADV
    36 PGM
    08  08
    71 SBR            Fij
    98 ADV
    02  2
    01  1
344 00  0
345 00  0
    42 STD
    02  03
    36 PGM
349 11  11

[illegible]
    43 RCL
    99 PRT
    42 STD
    45  45
    43 RCL
    18  18
    99 PRT
    42 STD
    46  46
    43 RCL
    19  19
    99 PRT
    42 STD
354 47  47
355 43 RCL
356 20  20
357 99 PRT
358 42 STD
359 48  48

[illegible]
417 49 PRI
418 59  59
419 76 LBL

[illegible]
    53  53
    99 PRT
    98 ADV
    91 R/S
    00  0
    00  0
464 00  0
465 00  0
466 00  0
467 00  0
    00  0
    00  0
    00  0
    00  0
    00  0
    00  0
    00  0
475 00  0
    00  0
    00  0
478 00  0
479 00  0
```

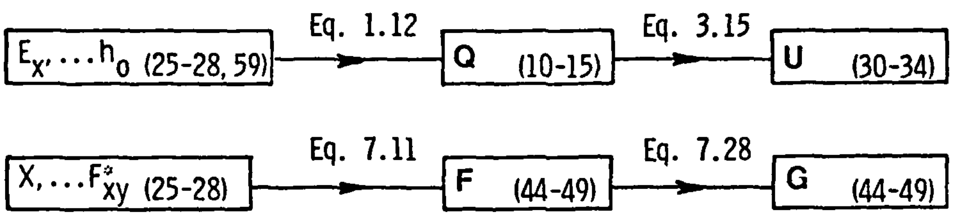
	T300/5208		B(4)/5505	
	SI	**ENGLISH**	**SI**	**ENGLISH**
INPUT	E	E	E	E
	181.000 09	26.251 06	204.000 09	29.587 06
	10.300 09	1.494 06	18.500 09	2.683 06
	280.000-03	280.000-03	230.000-03	230.000-03
	7.170 09	1.040 06	5.590 09	810.732 03
	H	H	H	H
	125.000-06	4.925-03	125.000-06	4.925-03
	Q	Q	Q	Q
	181.311 09	26.369 06	204.983 09	29.729 06
	10.346 09	1.501 06	18.589 09	2.696 06
	2.897 09	420.149 03	4.276 09	620.089 03
	7.170 09	1.040 06	5.590 09	810.732 03
	S	S	S	S
	5.525-12	38.094-09	4.902-12	33.799-09
	97.[illegible]-12	669.417-09	54.054-12	372.703-09
	-1.547-12	-10.666-09	-1.127-12	-7.774-09
	139.470-12	961.646-09	178.891-12	1.233-06
	U	U	U	U
	76.368 09	11.076 06	87.704 09	12.720 06
	85.732 09	12.434 06	93.197 09	13.517 06
	19.710 09	2.859 06	24.083 09	3.493 06
	22.607 09	3.279 06	28.358 09	4.113 06
	26.880 09	3.899 06	29.673 09	4.304 06
	A	A	A	A
	22.7[illegible] 06	124.365 03	25.6[illegible] 06	146.417 03
	1.29[illegible] 06	7.190 03	2.[illegible]24 06	13.178 03
	262.116 03	2.069 03	534.429 03	3.654 03
	896.150 03	5.121 03	699.750 03	3.492 03
	AI	AI	AI	AI
	44.199-09	7.735-06	19.216-09	6.563-06
	776.599-09	135.422-06	432.412-09	75.676-06
	-12.[illegible]76-09	-2.166-06	-4.020-09	-1.578-06
	1.[illegible]-06	195.258-06	1.421-06	250.447-06
INPUT	1.500 09	217.549 03	1.260 09	182.741 03
	1.500 09	217.549 03	2.500 09	362.592 03
	40.000 06	5.801 03	61.000 06	8.847 03
	246.000 06	35.679 03	202.000 06	29.297 03
	68.000 06	9.862 03	67.000 06	9.717 03
	F*	F*	F*	F
	-500.000-03	-500.000-03	-500.000-03	-500.000-03
	F	F	F	F
	444.444-21	21.129-12	317.460-21	15.092-12
	101.626-18	4.831-09	21.156-18	1.358-09
	-3.360-18	-159.753-12	-1.538-18	-120.654-12
	216.263-18	10.281-09	222.767-18	10.591-09
	0.000 00	0.000 00	393.651-12	2.714-06
	20.925-09	144.347-06	11.443-09	78.899-06
	G	G	G	G
	12.104 03	12.004 03	10.374 03	10.374 03
	10.681 03	10.681 03	27.646 03	27.646 03
	-3.069 03	-3.069 03	-2.989 03	-2.989 03
	11.118 03	11.118 03	6.961 03	6.961 03
	60.647 00	60.647 00	129.616 00	129.616 00
	216.596 00	216.596 00	214.398 00	214.398 00
	U'	U'	U'	U'
	11.076 06	76.368 09	12.720 06	87.704 09
	12.434 06	85.732 09	13.517 06	93.197 09
	2.859 06	19.710 09	3.493 06	24.083 09
	3.279 06	22.607 09	4.113 06	28.358 09
	3.899 06	26.880 09	4.304 06	29.673 09
	H'	H'	H'	H'
	4.925-03	125.000-06	4.925-03	125.000-06

	AS/3501 SI	AS/3501 ENGLISH	SCOTCHPLY 1002 SI	SCOTCHPLY 1002 ENGLISH
INPUT	E	E	E	E
	138.000 09	20.015 06	38.600 09	5.598 06
	8.960 09	1.299 06	8.270 09	1.199 06
	300.000-03	300.000-03	260.000-03	260.000-03
	7.100 09	1.030 06	4.140 09	600.415 03
	H	H	H	H
	125.000-06	4.925-03	125.000-06	4.925-03
	Q	Q	Q	Q
	[illegible]	20.132 06	39.167 09	5.681 06
	[illegible]	1.307 06	8.392 09	1.217 06
	2.704 09	392.139 03	2.182 09	316.412 03
	7.100 09	1.030 06	4.140 09	600.415 03
	S	S	S	S
	[illegible]	49.964-09	25.907-12	178.627-09
	[illegible]	769.531-09	120.919-12	833.736-09
	[illegible]	-14.989-09	-6.736-12	-46.443-09
	140.845-12	971.127-09	241.546-12	1.665-06
	U	U	U	U
	[illegible]	[illegible]	20.450 09	2.966 06
	[illegible]	3.412 06	15.128 09	2.212 06
	14.252 09	2.167 06	3.129 09	462.872 03
	16.956 09	2.459 06	5.511 09	799.304 03
	[illegible]	[illegible]	7.469 09	1.083 06
	A	A	A	A
	[illegible]	44.151 03	4.396 06	[illegible]
	[illegible]	1.428 03	1.049 06	5.384 03
	[illegible]	2.141 03	272.725 03	1.556 03
	[illegible]	5.171 03	517.500 03	2.967 03
	A*	A*	A*	A*
	[illegible]	10.145-06	232.254-09	36.269-06
	[illegible]	156.150-06	967.352-09	169.237-06
	[illegible]	-2.343-06	-57.336-09	-9.410-06
	[illegible]	197.133-06	1.932-06	335.164-06
INPUT				
	[illegible]	209.162 03	1.062 09	154.[illegible] 03
	[illegible]	209.162 03	617.000 06	89.470 03
	[illegible]	7.488 03	31.000 06	4.496 03
	[illegible]	[illegible]	118.000 06	17.114 03
	[illegible]	[illegible]	79.000 06	11.442 03
	F	F	F	F
	[illegible]	-500.000-03	-500.000-03	-500.000-03
	F	F	F	F
	[illegible]	21.706-12	1.524-18	[illegible]
	[illegible]	4.264-09	273.172-18	12.656-09
	[illegible]	-154.121-12	-10.271-18	-488.103-12
	115.[illegible]-18	5.497-09	192.901-18	9.171-09
	[illegible] 00	0.000 00	-697.725-12	-4.311-06
	14.488-09	44.895-06	23.783-09	163.987-06
	[illegible]	[illegible]	1.614 03	1.614 03
	7.467 03	7.467 03	15.182 03	18.182 03
	-1.746 03	-1.746 03	1.712 03	1.712 03
	5.828 03	5.828 03	3.106 03	3.106 03
	24.173 00	24.173 00	24.563 00	24.563 00
	[illegible]	[illegible]	198.658 00	198.658 00
	U*	U*	U*	U*
	[illegible]	54.660 09	2.966 06	20.450 09
	[illegible]	44.209 09	2.212 06	15.128 09
	2.167 06	14.252 09	462.872 03	3.129 09
	2.459 06	16.956 09	799.304 03	5.511 09
	[illegible]	21.352 09	1.083 06	7.469 09
	H*	H*	H*	H*
	4.925-03	125.000-06	4.925-03	125.000-06

	KEVLAR 49/EPOXY SI	KEVLAR 49/EPOXY ENGLISH	ALUMINUM SI	ALUMINUM ENGLISH
INPUT	E	E	E	E
	76.000 09	11.022 06	69.000 09	10.007 06
	5.500 09	797.679 03	69.000 09	10.007 06
	340.000-03	340.000-03	300.000-03	300.000-03
	2.300 09	333.575 03	26.538 09	3.849 06
	H	H	H	H
	125.000-06	4.925-03	1.000 00	1.000 00
	Q	Q	Q	Q
	76.641 09	11.115 06	75.824 09	10.997 06
	5.546 09	804.409 03	75.824 09	10.997 06
	1.886 09	273.499 03	22.747 09	3.299 06
	2.300 09	333.575 03	26.538 09	3.849 06
	S	S	S	S
	13.158-12	90.724-09	14.493-12	99.928-09
	181.818-12	1.254-06	14.493-12	99.928-09
	-4.474-12	-30.846-09	-4.348-12	-29.878-09
	434.783-12	2.998-06	37.681-12	259.812-09
	U	U	U	U
	32.442 09	4.705 06	75.824 09	10.997 06
	35.547 09	5.156 06	0.000 00	0.000 00
	8.652 09	1.255 06	40.000-03 ≈0	88.455-03 ≈0
	10.538 09	1.528 06	22.747 09	3.299 06
	10.952 09	1.588 06	26.538 09	3.849 06
	A	A	A	A
	9.580 06	54.744 03	75.824 09	10.997 06
	693.300 03	3.962 03	75.824 09	10.997 06
	235.722 03	1.347 03	22.747 09	3.299 06
	287.500 03	1.643 03	26.538 09	3.849 06
	AI	AI	AI	AI
	105.263-09	18.421-06	14.493-12	99.928-09
	1.455-06	254.545-06	14.493-12	99.928-09
	-35.789-09	-6.263-06	-4.348-12	-29.878-09
	3.478-06	608.696-06	37.681-12	259.812-09
INPUT	[illegible]	[illegible]	[illegible]	[illegible]
	1.400 09	203.046 03	400.000 06	58.[illegible] 03
	235.000 06	34.083 03	400.000 06	58.[illegible] 03
	12.000 06	1.740 03	400.000 06	58.[illegible] 03
	53.000 06	7.687 03	400.000 06	58.[illegible] 03
	34.000 06	4.931 03	230.000 06	[illegible] 03
	F[illegible]	F[illegible]	F[illegible]	F[illegible]
	-500.000-03	-500.000-03	-500.000-03	-500.000-03
	F	F	F	F
	2.040-18	144.502-12	6.250-18	297.131-12
	1.572-15	74.750-09	6.250-18	297.131-12
	-34.566-18	-1.643-09	-3.125-18	-148.5[illegible]-12
	865.052-18	41.125-09	18.904-18	899.[illegible]96-12
	-1.541-09	-24.415-06	0.000 00	0.000 00
	64.465-09	444.489-06	0.000 00	0.000 00
	G	G	G	G
	13.454 03	13.454 03	28.387 03	28.387 03
	47.657 03	47.657 03	28.387 03	28.387 03
	2.069 03	2.069 03	1.976 03	1.976 03
	4.576 03	4.576 03	13.314 03	13.314 03
	-149.922 00	-149.622 00	0.000 00	0.000 00
	350.873 00	350.873 00	0.000 00	0.000 00
	U*	U*	U*	U*
	4.705 06	32.442 09	10.997 06	75.824 09
	5.156 06	35.547 09	0.000 00	0.000 00
	1.255 06	8.652 09	5.801-06 ≈0	609.997 00 ≈0
	1.528 06	10.538 09	3.299 06	22.747 09
	1.588 06	10.952 09	3.849 06	26.538 09
	H*	H*	H*	H*
	4.925-03	125.000-06	39.400 00	25.381-03

NOTES

AFWAL/MLBM CARD-MODULE COMBO FOR TI-59				
SELECTED PLY DATA CARD D				COMBO -1
AL				SI↔ENGLISH
T-300	B	AS	SCOTCH	KEVLAR



Register locations are shown in parentheses. Equation and Table numbers are those in Introduction to Composite Materials, Tsai and Hahn.

COMBO #1 SELECTED PLY DATA

STEP	PROCEDURE	PRESS	DISPLAY
1	Enter material properties		
a	T300/5208	A	216.59641
b	B(4)/5505	B	214.39805
c	AS/3501	C	130.57541
d	Scotchply 1002	D	198.05771
e	Kevlar 49/Epoxy	E	350.87335
f	Aluminum	A'	0
2	Convert SI → English	E'	39.4

A pre-recorded data card should be made for each material in order to facilitate using Combos 4 and 4P. This entails recording the data generated by Combo 1 into Bank #3 (30-59) of a magnetic card. To do this, enter the material properties of the material of interest by pushing the appropriate button. Push [3] [2nd] [Write] and feed a blank magnetic card through the card reader. This has recorded the necessary data. Label the card and save it. Two materials may be put on each card, one on each side. For more information, consult the manuel that came with your TI-59.

COMBO 1 PLY DATA (SELECTED) 28 JUL 81

```
000  76 LBL
001  11  A
002  47 CMS
003  57 ENG
004  01  1     T300-
005  08  8     5208
006  01  1
007  52 EE
008  09  9
009  42 STO
010  25  25    Ex
011  01  1
012  00  0
013  03  3
014  52 EE
015  08  8
016  42 STO
017  26  26    Ey
018  07  7
019  01  1
020  07  7
021  52 EE
022  07  7
023  42 STO
024  27  27    Es
025  93  .
026  02  2
027  08  8
028  42 STO
029  28  28    Vx
030  01  1
031  02  2
032  05  5
033  52 EE
034  06  6
035  94 +/-
036  42 STO    ho
037  59  59
038  71 SBR
039  35 1/X
040  36 PGM
041  08  08
042  10 E'     x,...
043  71 SBR
044  45 YX
---------------
045  76 LBL
046  35 1/X
047  36 PGM
048  01  01
049  71 SBR    Qij
050  57 ENG
051  36 PGM
052  01  01
053  71 SBR    Ui
054  52 EE
055  92 RTN
---------------
056  76 LBL
057  45 YX
058  36 PGM
059  08  08
```

```
060  71 SBR
061  98 ADV    Fij
062  36 PGM
063  08  08
064  71 SBR
065  80 GRD    Gij
066  43 RCL
067  16  16
068  42 STO
069  44  44
070  43 RCL
071  17  17
072  42 STO
073  45  45
074  43 RCL
075  18  18
076  42 STO
077  46  46
078  43 RCL
079  19  19
080  42 STO
081  47  47
082  43 RCL
083  20  20
084  42 STO
085  48  48
086  43 RCL
087  21  21
088  42 STO
089  49  49
090  91 R/S
---------------
091  76 LBL
092  13  C
093  47 CMS
094  57 ENG
095  01  1     AS-
096  03  3     3501
097  08  8
098  52 EE
099  09  9
100  42 STO
101  25  25
102  08  8
103  09  9
104  06  6
105  52 EE
106  07  7
107  42 STO
108  26  26
109  07  7
110  01  1
111  52 EE
112  08  8
113  42 STO
114  27  27
115  93  .
116  03  3
117  42 STO
118  28  28
119  01  1
```

```
120  02  2
121  05  5
122  52 EE
123  06  6
124  94 +/-
125  42 STO
126  59  59
127  71 SBR
128  35 1/X
129  01  1
130  04  4
131  04  4
132  07  7
133  52 EE
134  06  6
135  42 STO
136  23  23
137  42 STO
138  24  24
139  05  5
140  01  1
141  07  7
142  52 EE
143  05  5
144  42 STO
145  25  25
146  02  2
147  00  0
148  06  6
149  52 EE
150  06  6
151  42 STO
152  26  26
153  09  9
154  03  3
155  52 EE
156  06  6
157  42 STO
158  27  27
159  93  .
160  05  5
161  94 +/-
162  42 STO
163  28  28
164  71 SBR
165  45 YX
---------------
166  76 LBL
167  14  D
168  47 CMS
169  57 ENG
170  03  3     Scotca-
171  08  8     Ply
172  06  6     1002
173  52 EE
174  08  8
175  42 STO
176  25  25
177  08  8
178  02  2
179  07  7
```

```
180  52 EE
181  07  7
182  42 STO
183  26  26
184  04  4
185  01  1
186  04  4
187  52 EE
188  07  7
189  42 STO
190  27  27
191  93  .
192  02  2
193  06  6
194  42 STO
195  28  28
196  01  1
197  02  2
198  05  5
199  52 EE
200  06  6
201  94 +/-
202  42 STO
203  59  59
204  71 SBR
205  35 1/X
206  01  1
207  00  0
208  06  6
209  02  2
210  52 EE
211  06  6
212  42 STO
213  23  23
214  06  6
215  01  1
216  52 EE
217  07  7
218  42 STO
219  24  24
220  03  3
221  01  1
222  52 EE
223  06  6
224  42 STO
225  25  25
226  01  1
227  01  1
228  08  8
229  52 EE
230  06  6
231  42 STO
232  26  26
233  07  7
234  02  2
235  52 EE
236  06  6
237  42 STO
238  27  27
239  93  .
```

COMBO 1 PLY DATA (SELECTED) 28 JUL 81

240	05	5
241	94	+/-
242	42	STO
243	28	28
244	71	SBR
245	45	[illegible]
246	76	LBL
247	[illegible]	A'
248	47	CMS
249	57	ENG
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	52	EE
[illegible]	[illegible]	[illegible]
[illegible]	42	STO
[illegible]	15	15
[illegible]	42	STO
[illegible]	16	16
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	42	STO
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	42	STO
[illegible]	18	18
269	01	1
270	42	STO
[illegible]	59	59
[illegible]	71	SBR
[illegible]	35	1/X
[illegible]	04	4
[illegible]	52	EE
[illegible]	08	8
[illegible]	42	STO
[illegible]	23	23
[illegible]	42	STO
[illegible]	24	24
[illegible]	42	STO
[illegible]	25	25
[illegible]	42	STO
[illegible]	26	26
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	52	EE
[illegible]	[illegible]	[illegible]
[illegible]	42	STO
[illegible]	[illegible]	27
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	42	STO
[illegible]	[illegible]	[illegible]
[illegible]	71	SBR
297	45	[illegible]
298	76	LBL
299	10	E'

Al

300	06	6
301	08	8
302	09	9
303	05	5
304	35	1/X
305	49	PRD
306	30	30
307	49	PRD
308	31	31
309	49	PRD
310	32	32
311	49	PRD
312	33	33
313	49	PRD
314	34	34
315	95	=
316	03	3
317	09	9
318	93	.
319	04	4
320	49	PRD
321	53	53
[illegible]	[illegible]	[illegible]
[illegible]	76	LBL
[illegible]	[illegible]	B'
[illegible]	[illegible]	CMS
[illegible]	[illegible]	ENG
[illegible]	03	3
[illegible]	00	0
[illegible]	04	4
[illegible]	52	EE
[illegible]	04	[illegible]
[illegible]	42	STO
[illegible]	25	25
[illegible]	01	1
[illegible]	08	8
[illegible]	93	.
[illegible]	05	5
[illegible]	52	EE
[illegible]	04	[illegible]
[illegible]	42	STO
[illegible]	26	26
[illegible]	93	.
[illegible]	02	2
[illegible]	03	3
[illegible]	42	STO
[illegible]	28	28
[illegible]	05	5
[illegible]	93	.
[illegible]	05	5
350	09	9
[illegible]	52	EE
[illegible]	09	[illegible]
[illegible]	42	STO
[illegible]	[illegible]	[illegible]
[illegible]	01	[illegible]
[illegible]	02	[illegible]
357	05	[illegible]
358	52	EE
359	06	6

B(4)/5505

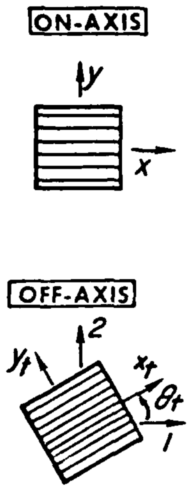
SI → Engl.

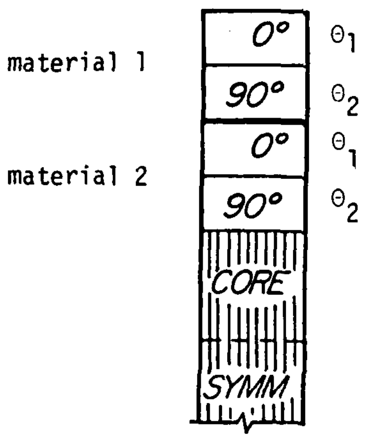
360	94	+/-
361	42	STO
362	59	59
[illegible]	71	SBR
364	35	1/X
365	01	1
[illegible]	02	2
[illegible]	06	6
[illegible]	52	EE
369	07	[illegible]
[illegible]	42	STO
[illegible]	23	23
[illegible]	02	[illegible]
[illegible]	05	[illegible]
[illegible]	52	EE
[illegible]	08	8
[illegible]	42	STO
[illegible]	24	24
378	06	6
[illegible]	01	1
[illegible]	52	EE
[illegible]	06	[illegible]
[illegible]	42	STO
[illegible]	25	25
[illegible]	02	[illegible]
[illegible]	00	0
[illegible]	02	[illegible]
[illegible]	52	EE
[illegible]	06	[illegible]
389	42	STO
390	26	26
[illegible]	06	6
[illegible]	07	[illegible]
[illegible]	52	EE
[illegible]	06	6
[illegible]	42	STO
[illegible]	[illegible]	27
[illegible]	[illegible]	[illegible]
[illegible]	05	5
[illegible]	94	+/-
[illegible]	42	STO
[illegible]	28	28
[illegible]	71	SBR
[illegible]	45	[illegible]
404	76	LBL
405	15	E
406	47	CMS
407	57	ENG
[illegible]	07	7
[illegible]	06	6
[illegible]	52	EE
[illegible]	09	[illegible]
[illegible]	42	STO
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	05	5
[illegible]	52	EE
[illegible]	08	8
[illegible]	42	STO
419	26	26

Kevlar 49/ Epoxy

420	02	2
[illegible]	03	3
[illegible]	52	EE
[illegible]	08	8
[illegible]	42	STO
[illegible]	[illegible]	27
[illegible]	93	.
[illegible]	03	3
[illegible]	04	4
[illegible]	42	STO
[illegible]	28	28
[illegible]	01	[illegible]
[illegible]	02	[illegible]
[illegible]	05	5
[illegible]	52	EE
[illegible]	06	6
[illegible]	94	+/-
[illegible]	42	STO
[illegible]	59	59
[illegible]	71	SBR
440	35	1/X
[illegible]	01	1
[illegible]	04	4
[illegible]	52	EE
[illegible]	08	8
[illegible]	42	STO
[illegible]	23	23
447	02	[illegible]
448	03	[illegible]
[illegible]	05	5
[illegible]	52	EE
[illegible]	[illegible]	[illegible]
[illegible]	42	STO
[illegible]	24	[illegible]
[illegible]	01	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	EE
[illegible]	06	[illegible]
[illegible]	42	STO
[illegible]	25	[illegible]
[illegible]	05	[illegible]
[illegible]	03	[illegible]
[illegible]	52	EE
[illegible]	06	[illegible]
[illegible]	42	STO
[illegible]	26	26
[illegible]	03	[illegible]
[illegible]	04	4
[illegible]	52	EE
[illegible]	06	[illegible]
[illegible]	42	STO
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	05	5
[illegible]	94	+/-
[illegible]	43	STO
476	28	28
477	71	SBR
478	45	[illegible]
479	00	0

NOTES

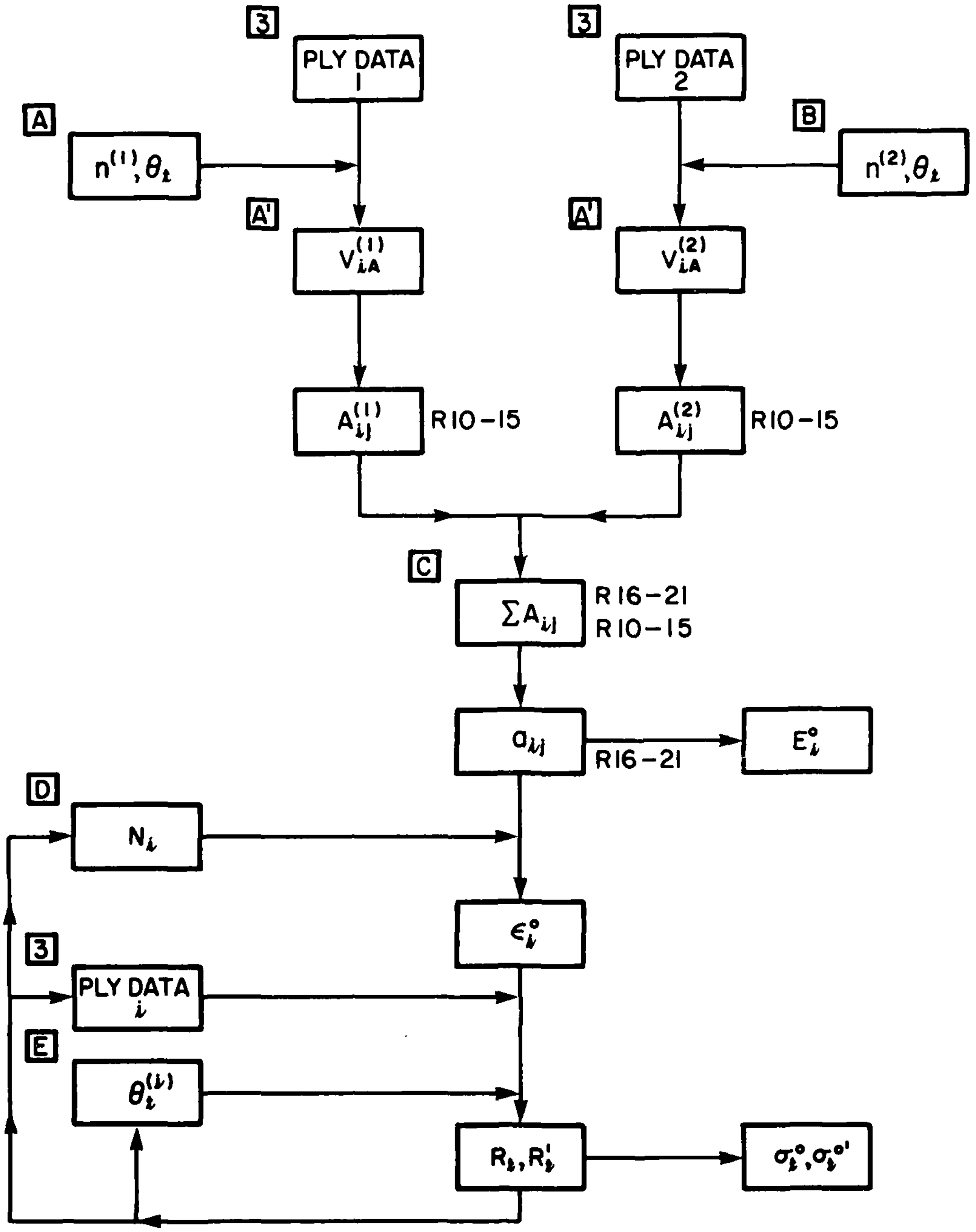




$$[0^{(1)}/90^{(1)}/0^{(2)}/90^{(2)}/C_2]_s$$

EXAMPLE OF LAMINATE STACKING SEQUENCE

COMBO #4P (PRT)
HYBRID: IN-PLANE STIFFNESS AND STRENGTH



COMBO #4P HYBRID: IN-PLANE STIFFNESS AND STRENGTH

A' core	B'	C'	D'	E'
A material 1 $n^{(1)}, \Theta_t^{(1)}$	B material i $n^{(i)}, \Theta_t^{(i)}$	C $A_{ij}, a_{ij}, E_i^{\circ}, A_{ij}^{*}$	D $N_i \rightarrow \varepsilon_i^{\circ}$	E $\Theta_t \rightarrow R_t, \sigma^{\circ}$

00 USED	15 $A_{26}^{(i)}$	30 $U_1^{(i)}$	45 $G_{yy}^{(i)}$
01 USED	16 $\Sigma A_{11}^{(i)}, a_{11}, G_{xx}^{(i)}$	31 $U_2^{(i)}$	46 $G_{xy}^{(i)}$
02 USED	17 $\Sigma A_{22}^{(i)}, a_{22}, G_{yy}^{(i)}$	32 $U_3^{(i)}$	47 $G_{ss}^{(i)}$
03 USED	18 $\Sigma A_{12}^{(i)}, a_{12}, G_{xy}^{(i)}$	33 $U_4^{(i)}$	48 $G_x^{(i)}$
04 USED	19 $\Sigma A_{66}^{(i)}, a_{66}, G_{ss}^{(i)}$	34 $U_5^{(i)}$	49 $G_y^{(i)}$
05 $n^{(i)}$, c	20 $\Sigma A_{16}^{(i)}, a_{16}, G_x^{(i)}$	35 Θ	50
06 R_t	21 $\Sigma A_{26}^{(i)}, a_{26}, G_y^{(i)}$	36 $V_0^{(i)}$	51
07 R_t'	22 $\lvert A \rvert$	37 $V_1^{(i)}$	52
08 1/h	23 ε_1°	38 $V_3^{(i)}$	53 p
09 h	24 ε_2°	39 $V_2^{(i)}$, USED	54 q
10 $A_{11}^{(i)}$	25 ε_6°	40 $V_4^{(i)}$	55 r
11 $A_{22}^{(i)}$	26 N_1, 0	41 Θ	56 USED
12 $A_{12}^{(i)}$	27 N_2, 0	42 USED	57 USED
13 $A_{66}^{(i)}$	28 N_6, 0	43 USED	58 USED
14 $A_{16}^{(i)}$	29 USED	44 $G_{xx}^{(i)}$	59 h_0

COMBO #4P HYBRID: IN-PLANE STIFFNESS AND STRENGTH

STEP	PROCEDURE	PRESS	PRINTER LABEL	PRINTOUT	CALCULATOR PROMPTER
0	Enter ply data #1	3	-	-	3
1a	Enter $n^{(1)}$	A	N1	$n^{(1)}$	n/2
b	Θ_1	R/S	-	Θ_1	n/2 - 1
c	Θ_2	R/S	-	Θ_2	n/2 - 2
. . .	. . .	. . .		. . .	. . .
	$\Theta_{n/2-1}$	R/S	-	$\Theta_{n/2-1}$	1
*	$\Theta_{n/2}$	R/S	-	$\Theta_{n/2}$	0
			SYM		
2	Enter ply data #2	3	-	-	3
3a	Enter $n^{(2)}$	B	N2	$n^{(2)}$	n/2
b	Θ_1	R/S	-	Θ_1	n/2 - 1
c	Θ_2	R/S	-	Θ_2	n/2 - 2
. . .	. . .	. . .		. . .	. . .
	$\Theta_{n/2-1}$	R/S	-	$\Theta_{n/2-1}$	1
	$\Theta_{n/2}$	R/S	-	$\Theta_{n/2}$	0
			SYM		
4	Print A_{ij}, a_{ij} E_i^o, A_{ij}^*	C	A	A_{11}, A_{22}, A_{12}, A_{66}, A_{16}, A_{26}	
				a_{11}, a_{22}, a_{12}, a_{66}, a_{16}, a_{26}	
			E*	E_1^o, E_2^o, ν_{21}^o, E_6^o	
			A*	A_{11}^*, A_{22}^*, A_{12}^*, A_{66}^*, A_{16}^*, A_{26}^*	6.1

COMBO #4P CONTINUED

STEP	PROCEDURE	PRESS	PRINTER LABEL	PRINTOUT	CALCULATOR PROMPTER
5a	Enter N_1	D	N	N_1	6.2
b	N_2	R/S	-	N_2	6.6
c	N_6	R/S	-	N_6	60
6	Enter ply data (see note 1)	3	-	-	3
7	Enter Θ_t	E	↑	Θ_t	
			R + Σ	R_t, R_t'	
				$\sigma_t^\circ, \sigma_t^{\circ\prime}$	$\sigma^{\circ\prime}$

OPTIONS

*	For sandwich construction (see note 2)	A'	CR	when prompter = c c	
			SYM		
	Continue with step 4				

Notes:

1. Only one set of material properties, for either material 1 or material 2 may be kept in the storage registers at any one point in time. Therefore, to calculate the strength ratios and allowable stresses for a particular ply Θ_t, it is necessary to insure that the material properties correspond to the material that ply Θ_t is made from. Step 6 has the user enter these numbers using the pre-recorded ply data card described in program 1. This step can be emitted if a whole series of strength ratio calculations are to be performed for plies in one particular material. But the user is cautioned not to emit this step, if there is any doubt, to avoid large errors.

2. The number of equivalent plies of core material should be entered with material 2.

COMBO 4p HYBRID: IN–PLANE (PRT)

```
000  76  LBL
001  11   A
002  42  STO
003  05   05     n(1)
004  57  ENG
005  58  FIX
006  03   03
007  00   0
008  49  PRD
009  09   09
010  49  PRD
011  16   16
012  49  PRD
013  17   17
014  49  PRD
015  18   18
016  49  PRD
017  19   19
018  49  PRD
019  20   20
020  49  PRD
021  21   21
022  03   3
023  01   1
024  00   0
025  02   2
026  42  STO
027  02   02
028  36  PGM
029  11   11
030  71  SBR
031  90  LST
--------------
032  00   0
033  36  PGM
034  12   12
035  71  SBR
036  61  GTO
037  43  RCL     n(i)
038  05   05
039  99  PRT
040  98  ADV
041  65   ×
042  43  RCL
043  59   59
044  95   =
045  44  SUM     h
046  09   09
047  93   .
048  05   5
049  49  PRD     n/2
050  05   05
051  43  RCL     =t
052  05   05
053  91  R/S
054  99  PRT
055  94  +/-     θt
056  42  STO
057  35   35
058  01   1
059  42  STO
060  04   04
061  44  SUM
062  36   36
063  36  PGM
064  12   12
065  71  SBR
066  71  SBR
067  97  DSZ
068  05   05
069  00   00
070  51   51
071  71  SBR
072  53   (
--------------
073  76  LBL
074  16   A'
075  01   1
076  05   5
077  03   3
078  05   5
079  42  STO
080  02   02
081  36  PGM
082  11   11
083  71  SBR
084  90  LST
085  43  RCL     C
086  05   05
087  99  PRT
--------------
088  76  LBL
089  53   (
090  43  RCL
091  59   59
092  65   ×
093  02   2
094  95   =
095  36  PGM
096  12   12
097  71  SBR     Via
098  61  GTO
099  03   3
100  06   6
101  04   4
102  05   5
103  03   3
104  00   0
105  42  STO
106  02   02
107  36  PGM
108  11   11
109  71  SBR
110  90  LST
111  98  ADV
112  36  PGM
113  11   11
114  71  SBR
115  23  LNX     Aij(i)
116  43  RCL
117  10   10
118  44  SUM     ΣAij(i)
119  16   16
120  43  RCL
121  11   11
122  44  SUM
123  17   17
124  43  RCL
125  12   12
126  44  SUM
127  18   18
128  43  RCL
129  13   13
130  44  SUM
131  19   19
132  43  RCL
133  14   14
134  44  SUM
135  20   20
136  43  RCL
137  15   15
138  44  SUM
139  21   21
140  91  R/S
--------------
141  76  LBL
142  12   B
143  42  STO     n(2)
144  05   05
145  93   .
146  01   1
147  00   0
148  03   3
149  42  STO
150  02   02
151  36  PGM
152  11   11
153  71  SBR
154  90  LST
155  61  GTO
156  00   00
157  32   32
--------------
158  76  LBL
159  13   C
160  01   1
161  03   3
162  00   0
163  00   0
164  42  STO
165  02   02
166  36  PGM
167  11   11
168  71  SBR
169  90  LST
170  43  RCL
171  16   16
172  42  STO     Aij
173  10   10
174  99  PRT
175  43  RCL
176  17   17
177  42  STO
178  11   11
179  99  PRT
180  43  RCL
181  18   18
182  42  STO
183  12   12
184  99  PRT
185  43  RCL
186  19   19
187  42  STO
188  13   13
189  99  PRT
190  43  RCL
191  20   20
192  42  STO
193  14   14
194  99  PRT
195  43  RCL
196  21   21
197  42  STO
198  15   15
199  99  PRT
200  98  ADV
201  36  PGM
202  11   11
203  71  SBR
204  35  1/X
205  43  RCL
206  16   16     Aij
207  99  PRT
208  43  RCL
209  17   17
210  99  PRT
211  43  RCL
212  18   18
213  99  PRT
214  43  RCL
215  19   19
216  99  PRT
217  43  RCL
218  20   20
219  99  PRT
220  43  RCL
221  21   21
222  99  PRT
223  98  ADV
224  01   1
225  07   7
226  05   5
227  01   1
228  42  STO
229  02   02
230  36  PGM
231  11   11
232  71  SBR
233  90  LST
234  43  RCL
235  09   09
236  35  1/X
237  42  STO
238  08   08
239  55   ÷
```

COMBO 4p HYBRID: IN-PLANE (PRT)

Step	Code	Key	Note
240	43	RCL	
241	16	16	
242	95	=	E_i^o
243	99	PRT	
244	43	RCL	
245	08	08	
246	55	÷	
247	43	RCL	
248	17	17	
249	95	=	
250	99	PRT	
251	43	RCL	
252	18	18	
253	55	÷	
254	43	RCL	
255	16	16	
256	95	=	
257	94	+/-	
258	99	PRT	
259	43	RCL	
260	08	08	
261	55	÷	
262	43	RCL	
263	19	19	
264	95	=	
265	99	PRT	
266	98	ADV	
267	01	1	
268	03	3	
269	05	5	
270	01	1	
271	42	STO	
272	02	02	
273	36	PGM	
274	11	11	
275	71	SBR	
276	90	LST	
277	43	RCL	
278	10	10	Aij
279	71	SBR	
280	23	LNX	
281	43	RCL	
282	11	11	
283	71	SBR	
284	23	LNX	
285	43	RCL	
286	12	12	
287	71	SBR	
288	23	LNX	
289	43	RCL	
290	13	13	
291	71	SBR	
292	23	LNX	
293	43	RCL	
294	14	14	
295	71	SBR	
296	23	LNX	
297	43	RCL	
298	15	15	
299	71	SBR	
300	23	LNX	
301	98	ADV	
302	06	6	
303	93	.	
304	01	1	
305	95	=	
306	91	R/S	
307	76	LBL	
308	14	D	
309	42	STO	
310	26	26	N_1
311	03	3	
312	01	1	
313	00	0	
314	00	0	
315	42	STO	
316	02	02	
317	36	PGM	
318	11	11	
319	71	SBR	
320	90	LST	
321	43	RCL	
322	26	26	
323	99	PRT	
324	06	6	
325	93	.	
326	02	2	
327	95	=	
328	91	R/S	
329	99	PRT	
330	42	STO	N_2
331	27	27	
332	06	6	
333	93	.	
334	06	6	
335	95	=	
336	91	R/S	
337	99	PRT	
338	42	STO	N_6
339	28	28	
340	98	ADV	
341	36	PGM	
342	11	11	
343	71	SBR	
344	35	1/X	Aij
345	36	PGM	
346	10	10	
347	71	SBR	
348	89	π	E_i^o
349	36	PGM	
350	10	10	
351	71	SBR	
352	34	√X	p,q,r,
353	43	RCL	
354	53	53	
355	42	STO	
356	00	00	
357	43	RCL	
358	54	54	
359	42	STO	
360	01	01	
361	43	RCL	
362	55	55	
363	42	STO	
364	03	03	
365	06	6	$\pm\Theta$
366	00	0	
367	95	=	
368	91	R/S	
369	76	LBL	
370	15	E	
371	42	STO	
372	41	41	Θ_t
373	43	RCL	
374	00	00	
375	42	STO	
376	53	53	
377	43	RCL	
378	01	01	
379	42	STO	
380	54	54	
381	43	RCL	
382	03	03	
383	42	STO	
384	55	55	
385	43	RCL	
386	44	44	
387	42	STO	
388	16	16	
389	43	RCL	
390	45	45	
391	42	STO	
392	17	17	
393	43	RCL	
394	46	46	
395	42	STO	
396	18	18	
397	43	RCL	
398	47	47	
399	42	STO	
400	19	19	
401	43	RCL	
402	48	48	
403	42	STO	
404	20	20	
405	43	RCL	
406	49	49	
407	42	STO	
408	21	21	
409	06	6	
410	00	0	
411	00	0	
412	42	STO	
413	02	02	
414	36	PGM	
415	11	11	
416	71	SBR	
417	90	LST	
418	43	RCL	
419	41	41	
420	99	PRT	
421	98	ADV	
422	36	PGM	
423	10	10	
424	71	SBR	
425	54	)	$E_i(\Theta_t')$
426	00	0	
427	42	STO	
428	26	26	$E_i^n=\sigma$
429	42	STO	
430	27	27	
431	42	STO	
432	28	28	
433	36	PGM	
434	08	08	
435	71	SBR	Gij
436	30	TAN	
437	03	3	
438	05	5	
439	04	4	
440	07	7	
441	07	7	
442	07	7	
443	42	STO	
444	02	02	
445	36	PGM	
446	11	11	
447	71	SBR	
448	90	LST	
449	43	RCL	R_t
450	06	06	
451	99	PRT	
452	43	RCL	R_t'
453	07	07	
454	99	PRT	
455	98	ADV	
456	43	RCL	
457	06	06	
458	55	÷	
459	43	RCL	
460	09	09	
461	95	=	σ_t^{o}
462	99	PRT	
463	43	RCL	
464	07	07	
465	55	÷	
466	43	RCL	
467	09	09	$\sigma_t^{o\prime}$
468	95	=	
469	99	PRT	
470	98	ADV	
471	91	R/S	
472	76	LBL	
473	[illegible]	[illegible]	
474	55	÷	→ Aij
475	[illegible]	[illegible]	
476	[illegible]	[illegible]	
477	95	=	
478	99	PRT	
479	92	RTN	

4P SAMPLE PROBLEM HYBRID: IN-PLANE STIFFNESS AND STRENGTH

LAMINATE: $[0^{(1)}/90^{(2)}]_s$ **MATERIAL 1:** T300/5208 **MATERIAL 2:** Scotchply 1002

PROCEDURE	KEY	PRINT
Enter $n^{(1)}$	A	[illegible]
Enter θ_1	R/S	[illegible]
Enter $n^{(2)}$	B	[illegible]
Enter θ_1	R/S	[illegible]
PRINT A_{ij}	C	[illegible] [illegible] [illegible] [illegible] 0.000 00 [illegible]
PRINT a_{ij}		[illegible] [illegible] [illegible] [illegible] [illegible] 0.000 00
PRINT E_i^o		E→ [illegible] 09 24.689 09 [illegible] 5.[illegible]55 09
PRINT A_{ij}^*		A→ [illegible] 09 [illegible] 09 [illegible] 09 [illegible] 09 [illegible] 00 0.000 00

PROCEDURE	KEY	PRINT
ENTER N_1 N_2 N_6	D	[illegible]
ENTER θ_t[1]	E	[illegible]
PRINT R_t R_t' σ^o $\sigma^{o\prime}$		[illegible]
ENTER θ_t[1]	E	[illegible]
PRINT R_t R_t' σ^o $\sigma^{o\prime}$		[illegible] [illegible] 03 [illegible] 00 657.314 06 1.357 09

[1] Remember to use pre-recorded data card for each material to insure that the correct material properties are in storage.

4P SAMPLE PROBLEM HYBRID: IN-PLANE STIFFNESS AND STRENGTH

LAMINATE: $[0_2^{(1)}/90_1^{(2)}]_s$ **MATERIAL 1:** T300/5208 **MATERIAL 2:** Scotchply 1002

PROCEDURE	KEY	PRINT	PROCEDURE	KEY	PRINT
			ENTER N_1	D	[illegible]
			N_2		[illegible]
			N_6		[illegible]
Enter $n^{(1)}$	A	[illegible]	ENTER θ_t[1]	E	[illegible]
Enter θ_1	R/S	[illegible]	PRINT R_t		[illegible]
θ_2	R/S	[illegible]	R_t'		[illegible]
			$\sigma°$		[illegible]
Enter $n^{(2)}$	B	[illegible]	$\sigma°'$		[illegible]
Enter θ_1	R/S	[illegible]	ENTER θ_t[1]	E	[illegible]
PRINT A_{ij}	C	[illegible]	PRINT R_t		[illegible]
			R_t'		[illegible] .129 06
			$\sigma°$		40[illegible].382 06
			$\sigma°'$		1.772 09
PRINT a_{ij}		[illegible]			
PRINT $E_i°$		[illegible]			
PRINT A_{ij}^*		[illegible]			

[1]Remember to use pre-recorded data card for each material to insure that the correct material properties are in storage.

4P SAMPLE PROBLEM HYBRID: IN-PLANE STIFFNESS AND STRENGTH

LAMINATE: $[90^{(1)}/0^{(2)}]_s$ MATERIAL 1: T300/5208 MATERIAL 2: Scotchply 1002

PROCEDURE	KEY	PRINT
Enter $n^{(1)}$	A	n1 1.000 00
Enter Θ_1	R/S	90.000 00 [illegible]
Enter $n^{(2)}$	B	n2 1.000 00
Enter Θ_1	R/S	0.000 00 [illegible]
PRINT A_{ij}	C	A 12.378 06 47.551 06 1.270 06 1.827 06 0.000 00 0.000 00
PRINT a_{ij}		21.708-09 21.368-09 -1.161-09 351.669-09 0.000 00 0.000 00
PRINT E°_i		E- 14.189 09 44.541 09 26.702-03 5.655 09
PRINT A^*_{ij}		A* 24.757 09 45.101 09 1.539 09 5.155 09 0.000 00 0.000 00

PROCEDURE	KEY	PRINT
ENTER N_1 N_2 N_6	D	N 1.000 00 0.000 00 0.000 00
ENTER Θ_t[1]	E	t 90.000 00
PRINT R_t R'_t σ° $\sigma^{\circ\prime}$		R+I 46.100 03 241.517 03 35.599 06 585.034 06
ENTER Θ_t[1]	E	t 0.000 00
PRINT R_t R'_t σ° $\sigma^{\circ\prime}$		R+I 230.498 03 360.194 03 460.996 06 720.187 06

[1]Remember to use pre-recorded data card for each material to insure that the correct material properties are in storage.

4P SAMPLE PROBLEM HYBRID: IN-PLANE STIFFNESS AND STRENGTH

LAMINATE: $[0_4^{(1)}/90_4^{(2)}]_s$ **MATERIAL 1:** T300/5208 **MATERIAL 2:** Scotchply 1002

PROCEDURE	KEY	PRINT
Enter $n^{(1)}$	A	N1 8.000 00
Enter Θ_1 Θ_2 Θ_3 Θ_4	R/S R/S R/S R/S	0.000 00 0.000 00 0.000 00 0.000 00 END
Enter $n^{(2)}$	B	N2 8.000 00
Enter Θ_1 Θ_2 Θ_3 Θ_4	R/S R/S R/S R/S	90.000 00 90.000 00 90.000 00 90.000 00 END
PRINT A_{ij}	C	A 190.203 06 49.513 06 5.079 06 11.310 06 0.000 00 0.000 00
PRINT a_{ij}		5.272-09 20.152-09 -540.7[illegible]2-12 16.417-09 0.000 00 0.000 00
PRINT E_i^o		E· 54.741 09 24.419 09 102.57[illegible]-03 5.155 09
PRINT A_{ij}^*		A* 95.101 09 24.757 09 2.579 09 5.655 09 0.000 00 0.000 00

PROCEDURE	KEY	PRINT
ENTER N_1 N_2 N_6	D	N 1.000 00 0.000 00 0.000 00
ENTER Θ_t[1]	E	T 0.000 00
PRINT R_t R_t' σ^o $\sigma^{o\prime}$		R-I 1.418 06 1.890 06 718.152 06 995.196 06
ENTER Θ_t[1]	E	T 90.000 00
PRINT R_t R_t' σ^o $\sigma^{o\prime}$		R-I 714.[illegible]28 03 2.714 06 257.[illegible]14 06 [illegible].[illegible]57 03

[1]Remember to use pre-recorded data card for each material to insure that the correct material properties are in storage.

4P SAMPLE PROBLEM HYBRID: IN-PLANE STIFFNESS AND STRENGTH

LAMINATE: $[0_2{}^{(1)}/90_2{}^{(2)}/c_2]_s$ MATERIAL 1: T300/5208 MATERIAL 2: Scotchply 1002

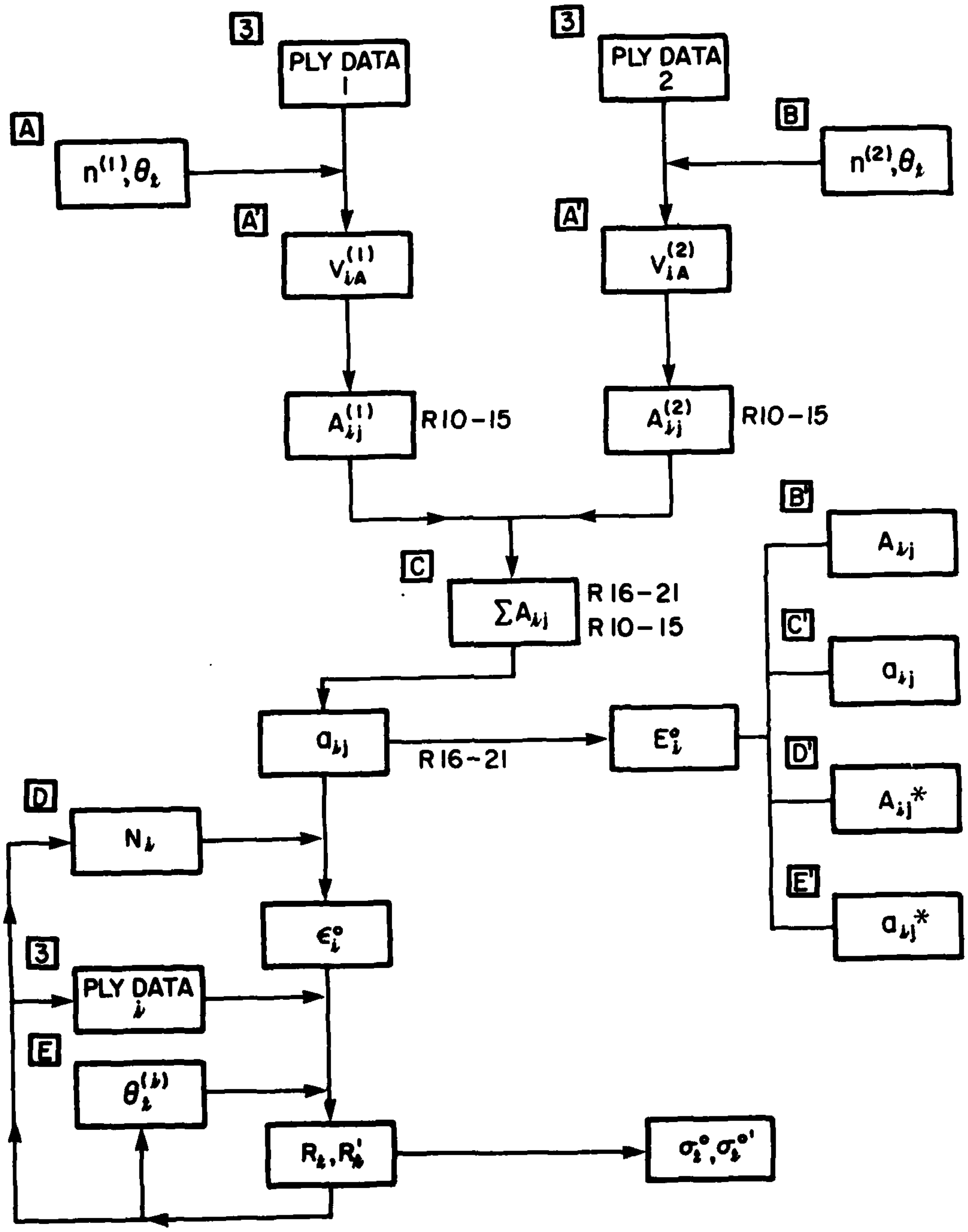
PROCEDURE	KEY	PRINT
Enter $n^{(1)}$	A	[illegible]
Enter θ_1	R/S	[illegible]
Enter θ_2	R/S	[illegible]
Enter $n^{(2)}$	B	[illegible]
Enter θ_1 θ_2	R/S R/S A'	[illegible]
PRINT A_{ij}	C	[illegible] [illegible] 06 [illegible] 06 [illegible] 06 [illegible] 00 0.000 00
PRINT a_{ij}		10.544-09 40.504-09 -1.092-09 176.835-09 0.000 00 0.000 00
PRINT E_i°		E* 58.227 09 16.459 09 102.570-03 3.770 09
PRINT A_{ij}^*		A* 6[illegible].401 09 16.504 09 1.693 09 3.770 09 0.000 00 0.000 00

PROCEDURE	KEY	PRINT
ENTER N_1 N_2 N_6	D	[illegible]
ENTER Θ_t[1]	E	[illegible]
PRINT R_t R_t' σ° $\sigma^{\circ\prime}$		[illegible]
ENTER Θ_t[1]	E	[illegible]
PRINT R_t R_t' σ° $\sigma^{\circ\prime}$		[illegible] [illegible] 330.309 06 904.679 06

[1]Remember to use pre-recorded data card for each material to insure that the correct material properties are in storage.

NOTES

COMBO #4
HYBRID: IN-PLANE STIFFNESS AND STRENGTH



COMBO #4 HYBRID: IN-PLANE STIFFNESS AND STRENGTH

A'	B'	C'	D'	E'
core	A_{ij}	a_{ij}	A^*_{ij}	a^*_{ij}
A material 1 $n^{(1)}, \Theta_t^{(1)}$	B material i $n^{(i)}, \Theta_t^{(i)}$	C E_i°	D $N_i \rightarrow \varepsilon_i^\circ$	E $\Theta_t \rightarrow R_t, \sigma^\circ$

00 USED	15 $A_{26}^{(i)}$	30 $U_1^{(i)}$	45 $G_{yy}^{(i)}$
01 USED	16 $\Sigma A_{11}^{(i)}, a_{11}, G_{xx}^{(i)}$	31 $U_2^{(i)}$	46 $G_{xy}^{(i)}$
02 USED	17 $\Sigma A_{22}^{(i)}, a_{22}, G_{yy}^{(i)}$	32 $U_3^{(i)}$	47 $G_{ss}^{(i)}$
03 USED	18 $\Sigma A_{12}^{(i)}, a_{12}, G_{xy}^{(i)}$	33 $U_4^{(i)}$	48 $G_x^{(i)}$
04 USED	19 $\Sigma A_{66}^{(i)}, a_{66}, G_{ss}^{(i)}$	34 $U_5^{(i)}$	49 $G_y^{(i)}$
05 $n^{(i)}$, c	20 $\Sigma A_{16}^{(i)}, a_{16}, G_x^{(i)}$	35 Θ	50
06 R_t	21 $\Sigma A_{26}^{(i)}, a_{26}, G_y^{(i)}$	36 $V_o^{(i)}$	51
07 R_t'	22 $\|A\|$	37 $V_1^{(i)}$	52
08 1/h	23 ε_i°	38 $V_3^{(i)}$	53 p
09 h	24 ε_2°	39 $V_2^{(i)}$, USED	54 q
10 $A_{11}^{(i)}$	25 ε_6°	40 $V_4^{(i)}$	55 r
11 $A_{22}^{(i)}$	26 N_1, 0	41 Θ	56 USED
12 $A_{12}^{(i)}$	27 N_2, 0	42 USED	57 USED
13 $A_{66}^{(i)}$	28 N_6, 0	43 USED	58 USED
14 $A_{16}^{(i)}$	29 USED	44 $G_{xx}^{(i)}$	59 h_o

COMBO #4 HYBRID: IN-PLANE STIFFNESS AND STRENGTH

STEP	PROCEDURE	PRESS	DISPLAY/PROMPTER
0	Enter ply data #1	3	3
1a	Enter $n^{(1)}$	A	n/2
b	Θ_1	R/S	n/2 - 1
c	Θ_2	R/S	n/2 - 2
.	.	.	.
.	.	.	.
.	.	.	.
	$\Theta_{n/2-1}$	R/S	1
	$\Theta_{n/2}$	R/S	0
2	Enter ply data #2	3	3
3a	Enter $n^{(2)}$	B	n/2
b	Θ_1	R/S	n/2 - 1
c	Θ_2	R/S	n/2 - 2
.	.	.	.
.	.	.	.
.	.	.	.
	$\Theta_{n/2-1}$	R/S	1
*	$\Theta_{n/2}$	R/S	0
4 **	Compute E_i°	C,R/S...	$E_1^\circ, E_2^\circ, \nu_{21}^\circ, E_6^\circ$, 6.1
5	Enter N_1	D	6.2
	N_2	R/S	6.6
	N_6	R/S	60

COMBO #4 CONTINUED

STEP	PROCEDURE	PRESS	DISPLAY/PROMPTER
6	Enter ply data (see note 1)	3	3
7	Enter Θ_t	E	R_t
		R/S	R_t'
		R/S	σ_t^o
		R/S	$\sigma_t^{o\prime}$
		R/S	60

OPTIONS

*	For sandwich construction (see note 2)	-	when prompter = c
		A'	0
	continue with step 4		
**	Calculate A_{ij}	B'	A_{11}, A_{22}, A_{12}, A_{66}, A_{16}, A_{26}, 6.1
	a_{ij}	C'	a_{11}, a_{22}, a_{12}, a_{66}, a_{16}, a_{26}, 6.1
	A^*_{ij}	D'	A^*_{11}, A^*_{22}, A^*_{12}, A^*_{66}, A^*_{16}, A^*_{26}, 6.1
	a^*_{ij}	E'	a^*_{11}, a^*_{22}, a^*_{12}, a^*_{66}, a^*_{16}, a^*_{26}, 6.1

Notes:

1. Only one set of material properties, for either material 1 or material 2 may be kept in the storage registers at any one point in time. Therefore, to calculate the strength ratios and allowable stresses for a particular ply Θ_t, it is necessary to insure that the material properties correspond to the material that ply Θ_t is made from. Step 6 has the user enter these numbers using the pre-recorded ply data card described in program 1. This step can be emitted if a whole series of strength ratio calculations are to be performed for plies in one particular material. But the user is cautioned not to emit this step, if there is any doubt, to avoid large errors.

2. The number of equivalent plies of core material should be entered with material 2.

COMBO 4 HYBRID: IN-PLANE

000–039	[illegible]		$n^{(1)}$, $n^{(i)}$, h
040	42	PRD	n/2=
041	05	05	
042	43	RCL	t
043	05	05	
044	91	R/S	
045	94	+/-	
046	42	STD	Θt
047	35	35	
048	01	1	
049	42	STD	
050	04	04	
051	44	SUM	
052	36	36	
053	36	PGM	
054	12	12	
055	71	SBR	
056	71	SBR	
057	97	DSZ	
058	05	05	
059	00	00	

060–100	[illegible]		C, Via, $A_{ij}^{(i)}$, $\sum A_{ij}^{(i)}$
101	76	LBL	$n^{(2)}$
102	15	E	
103	42	STD	
104	35	35	
105	00	0	
106	36	PGM	
107	12	12	
108	71	SBR	
109	61	GTO	
110	71	SBR	
111	35	[illegible]	
112	76	LBL	
113	13	C	
114	43	RCL	Aij
115	16	16	
116	42	STD	
117	10	10	
118	43	RCL	
119	17	17	

120–165	[illegible]		Aij, E_i^0
166	91	R/S	
167	43	RCL	
168	08	08	
169	55	÷	
170	43	RCL	
171	19	19	
172	95	=	
173	91	R/S	
174	06	6	
175	93	.	N_1
176	01	1	
177	95	=	
178	91	R/S	
179	76	LBL	

180–223	[illegible]		N^2, N^6, Aij, E_i^0, p, q, r, ↑Θ
224	91	R/S	
225	76	LBL	
226	15	E	
227	42	STD	Θ_t
228	41	41	
229	43	RCL	
230	00	00	
231	42	STD	
232	53	53	
233	43	RCL	
234	01	01	
235	42	STD	
236	54	54	
237	43	RCL	
238	03	03	
239	42	STD	

COMBO 4 HYBRID: IN-PLANE

240–290	[illegible]	[illegible]	
291	95	=	τ_t^0
292	91	R/S	
293	43	RCL	
294	07	07	
295	55	-	
296	43	RCL	$\tau_t^{0\prime}$
297	09	09	
298	95	=	
299	91	R/S	

300	06	6	
301	00	0	
302	95	=	
303	91	R/S	
304	71	SBR	
305	15	E	
306	91	R/S	
307	76	LBL	Aij
308	17	B'	
309	43	RCL	
310	10	10	
311	91	R/S	
312	43	RCL	
313	11	11	
314	91	R/S	
315	43	RCL	
316	12	12	
317	91	R/S	
318	43	RCL	
319	13	13	
320	91	R/S	
321	43	RCL	
322	14	14	
323	91	R/S	
324	43	RCL	
325	15	15	
326	91	R/S	
327	06	6	
328	93	.	$E_i^*(\theta_t)$
329	01	1	
330	95	=	
331	91	R/S	E_i^n-0
332	76	LBL	Aij
333	18	C'	
334	43	RCL	
335	16	16	
336	91	R/S	
337	43	RCL	
338	17	17	Gij
339	91	R/S	
340	43	RCL	Rt
341	18	18	
342	91	R/S	
343	43	RCL	R_t'
344	19	19	
345	91	R/S	
346	43	RCL	
347	20	20	
348	91	R/S	
349	43	RCL	
350	21	21	
351	91	R/S	
352	06	6	
353	93	.	
354	01	1	
355	95	=	
356	91	R/S	
357	76	LBL	$\dot{A}ij$
358	19	D'	
359	43	RCL	

360	10	10	
361	55	-	
362	43	RCL	
363	09	09	
364	95	=	
365	91	R/S	
366	43	RCL	
367	11	11	
368	55	-	
369	43	RCL	
370	09	09	
371	95	=	
372	91	R/S	
373	43	RCL	
374	12	12	
375	55	-	
376	43	RCL	
377	09	09	
378	95	=	
379	91	R/S	
380	43	RCL	
381	13	13	
382	55	-	
383	43	RCL	
384	09	09	
385	95	=	
386	91	R/S	
387	43	RCL	
388	14	14	
389	55	-	
390	43	RCL	
391	09	09	
392	95	=	
393	91	R/S	
394	43	RCL	
395	15	15	
396	55	-	
397	43	RCL	
398	09	09	
399	95	=	
400	91	R/S	
401	06	6	
402	93	.	
403	01	1	
404	95	=	
405	91	R/S	
406	76	LBL	$\overset{+}{A}ij$
407	10	E'	
408	43	RCL	
409	16	16	
410	65	×	
411	43	RCL	
412	09	09	
413	95	=	
414	91	R/S	
415	43	RCL	
416	17	17	
417	65	×	
418	43	RCL	
419	09	09	

420	95	=
421	91	R/S
422	43	RCL
423	18	18
424	65	×
425	43	RCL
426	09	09
427	95	=
428	91	R/S
429	43	RCL
430	19	19
431	65	×
432	43	RCL
433	09	09
434	95	=
435	91	R/S
436	43	RCL
437	20	20
438	65	×
439	43	RCL
440	09	09
441	95	=
442	91	R/S
443	43	RCL
444	21	21
445	65	×
446	43	RCL
447	09	09
448	95	=
449	91	R/S
450	06	6
451	93	.
452	01	1
453	95	=
454	91	R/S
455	00	0
456	00	0
457	00	0
458	00	0
459	00	0
460	00	0
461	00	0
462	00	0
463	00	0
464	00	0
465	00	0
466	00	0
467	00	0
468	00	0
469	00	0
470	00	0
471	00	0
472	00	0
473	00	0
474	00	0
475	00	0
476	00	0
477	00	0
478	00	0
479	00	0

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