AD A116654

(12)

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

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

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS
BEFORE COMPLETING FORM

1. REPORT NUMBER
AFWAL-TR-81-4183

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
INSTRUCTIONS FOR TI-59 COMBINED CARD/MODULE
CALCULATIONS FOR IN-PLANE PROPERTIES OF
SYMMETRIC HYBRID LAMINATES

5. TYPE OF REPORT & PERIOD COVERED
Final Technical Report
September - November 1981

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
Stella D. Gates

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Materials Laboratory (AFWAL/MLBM)
Air Force Wright Aeronautical Laboratories
Air Force Systems Command
Wright-Patterson AFB, OH 45433

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
24190310

11. CONTROLLING OFFICE NAME AND ADDRESS
Materials Laboratory (AFWAL/MLBM)
Air Force Wright Aeronautical Laboratories
Air Force Systems Command
Wright-Patterson AFB, OH 45433

12. REPORT DATE
March 1982

13. NUMBER OF PAGES
40

14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

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

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

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	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	-
$\sigma_t^o, \sigma_t^{o\prime}$	= 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	

$$\begin{tikzcd}
\boxed{E_x, \ldots h_o \ (25\text{-}28, 59)} \arrow[r, "\text{Eq. } 1.12"] & \boxed{Q \ (10\text{-}15)} \arrow[r, "\text{Eq. } 3.15"] & \boxed{U \ (30\text{-}34)} \\
\boxed{X, \ldots F^*_{xy} \ (25\text{-}28)} \arrow[r, "\text{Eq. } 7.11"] & \boxed{F \ (44\text{-}49)} \arrow[r, "\text{Eq. } 7.28"] & \boxed{G \ (44\text{-}49)}
\end{tikzcd}$$

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

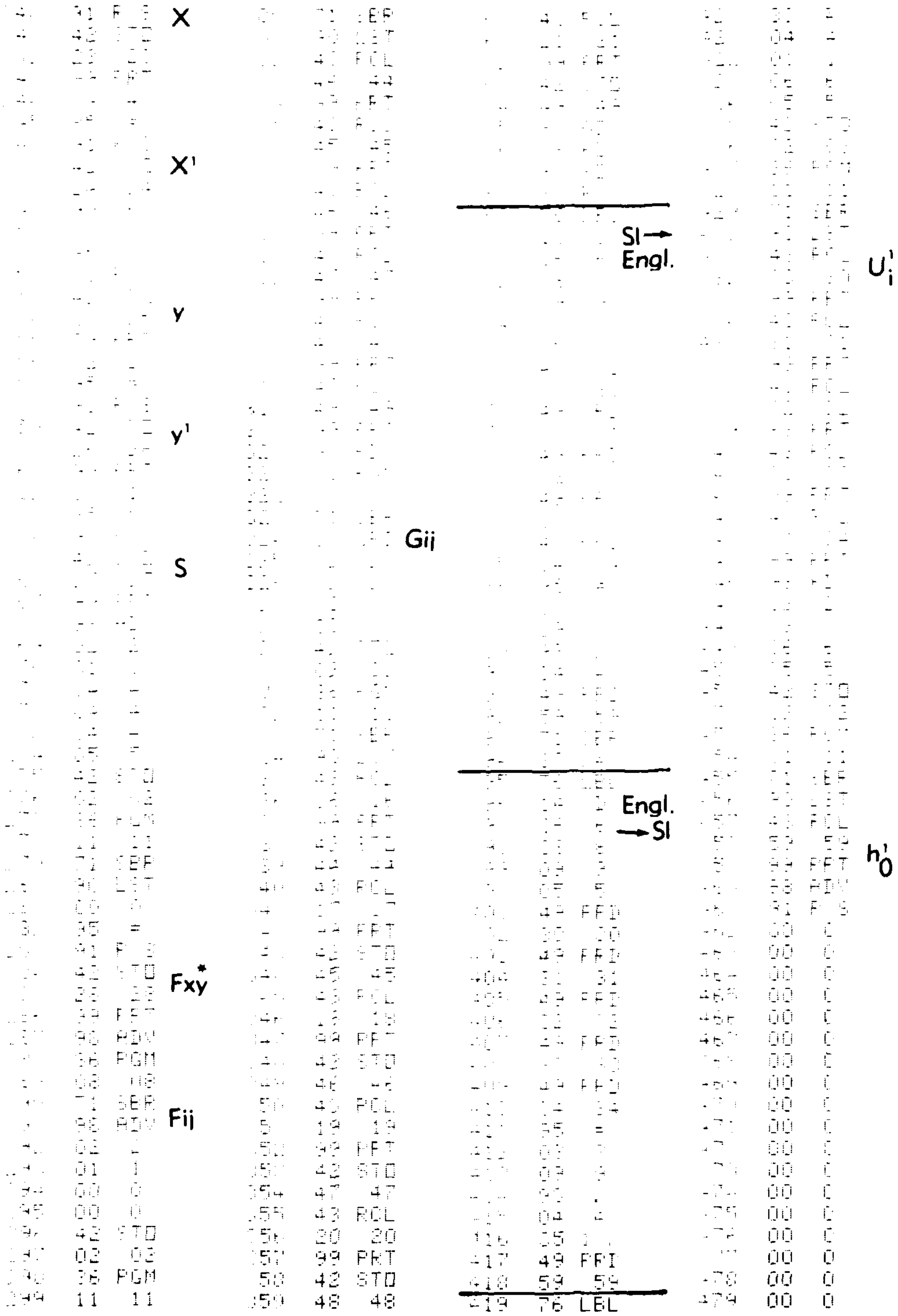
COMBO #IP CONTINUED

STEP	PROCEDURE	PRESS	PRINTER LABEL	PRINTOUT	CALCULATOR PROMPTER
3	Convert SI → English	C	U' H'	$U_1', U_2', U_3', U_4', U_5'$ h_o'	 h_o'
4	Convert English → SI	D	U' H'	$U_1', U_2', U_3', U_4', U_5'$ h_o'	 h_o'

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

```
000  76  LBL
001  11  A
002  47  CMS
003  57  ENG
004  58  FIX
005  03  03
006  01  1
007  93  .
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  15  15
021  99  PRT
022  01  1
023  95  =
024  91  R/S
025  42  STO    Ey
026  26  26
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  03  3
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



```
     42  STO
     35   =
     44  PRT
     98  ADV
     36  PGM
     08   08
     71  SBR
     98  ADV
     01   1
     00   0
 345 00   0
     42  STO
     02   02
     36  PGM
     11   11

 354 47   47
 355 43  RCL
 356 20   20
 357 99  PRT
 358 42  STO
 359 48   48

 417 49  PRD
 418 59   59
 419 76  LBL

     00   0
     00   0
 478 00   0
 479 00   0
```

```
               T300/5208                                  B(4)/5505

        SI               ENGLISH                   SI               ENGLISH
                                                                       E
         E                  E                       E              29.587 06
     181.000 09         26.251 06              204.000 09           2.683 06
      10.300 09          1.494 06               18.500 09         230.000-03
I    280.000-03        280.000-03              230.000-03         810.732 03
N      7.170 09          1.040 06                5.590 09
P
U                                                                      H
T        H                  H                       H               4.925-03
     125.000-06          4.925-03              125.000-06

         Q                  Q                       Q                  Q
     181.811 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
      97.087-12        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
      22.743 06        129.865 03               25.641 06         146.417 03
       1.293 06          7.390 03                2.124 06          12.178 03
     362.316 03          2.069 03              534.429 03           3.054 03
     896.850 03          5.121 03              598.750 03           3.392 03

         A'                 A'                      A'                 A'
      44.111-09          7.725-06               39.216-09           6.863-06
     773.299-09        135.422-06              432.412-09          75.676-06
     -12.376-09         -2.166-06              -44.020-09          -7.673-06
       1.115-06        195.258-06                1.431-06         250.447-06

       1.500 09        217.549 03                1.260 09         182.741 03
I      1.500 09        217.549 03                2.500 09         362.592 03
N     40.000 06          5.801 03               61.000 06           8.847 03
P    246.000 06         35.679 03              202.000 06          29.297 03
U     68.000 06          9.862 03               67.000 06           9.717 03
T
         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
     101.626-15          4.831-09               81.156-18           3.858-09
      -3.360-18       -159.753-12               -2.538-18        -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
      20.935-09        144.347-06               11.443-09          78.899-06

         G                  G                       G                  G
      12.004 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'             87.704 09
      11.076 06         76.368 09               12.720 06          93.197 09
      12.434 06         85.732 09               13.517 06          24.083 09
       2.859 06         19.710 09                3.493 06          28.358 09
       3.279 06         22.607 09                4.113 06          29.673 09
       3.899 06         26.880 09                4.304 06
                                                                       H'
         H'                 H'                      H'            125.000-06
       4.925-03        125.000-06                4.925-03
```

```
                     AS/3501                                  SCOTCHPLY 1002

              SI                ENGLISH                SI                ENGLISH
              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
INPUT      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
         138.811 09           20.132 06           39.167 09            5.681 06
           9.013 09            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
           7.246-12           49.964-09           25.907-12          178.627-09
         111.607-12          769.531-09          120.919-12          833.736-09
          -2.174-12          -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
          59.660 09            8.653 06           20.450 09            2.966 06
          64.899 09            9.412 06           15.388 09            2.232 06
          14.252 09            2.067 06            3.329 09          482.872 03
          16.956 09            2.459 06            5.511 09          799.304 03
          21.352 09            3.097 06            7.469 09            1.083 06

              A                    A                   A                    A
          17.351 06           99.151 03            4.896 06           27.977 03
           1.127 06            6.428 03            1.049 06            5.994 03
         338.000 03            1.921 03          272.725 03            1.558 03
         887.500 03            5.071 03          517.500 03            2.957 03

              A*                   A*                  A*                   A*
          57.971-09           10.145-06          207.254-09           36.269-06
         892.857-09          156.150-06          967.352-09          169.287-06
         -17.391-09           -3.043-06          -53.888-09           -9.430-06
           1.127-06          197.183-06            1.932-06          338.164-06

           1.447 09          209.869 03            1.062 09          154.030 03
           1.447 09          209.869 03          610.000 06           88.470 03
INPUT     51.700 06            7.498 03           31.000 06            4.496 03
         206.000 06           29.877 03          118.000 06           17.114 03
          93.000 06           13.488 03           72.000 06           10.442 03

              F                    F                   F                    F
        -500.000-03         -500.000-03         -500.000-03         -500.000-03

              F                    F                   F                    F
         477.598-21           22.706-12            1.544-18           73.386-12
          93.895-18            4.464-09          273.373-18           12.996-09
          -3.348-18         -159.171-12          -10.271-18         -488.303-12
         115.620-18            5.497-09          192.901-18            9.171-09
           0.000 00            0.000 00         -697.725-12           -4.811-06
          14.488-09           99.895-06           23.783-09          163.987-06

              G                    G                   G                    G
           7.776 03            7.776 03            1.914 03            1.914 03
           7.467 03            7.467 03           16.082 03           16.082 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
          14.173 00           14.173 00           24.563 00           24.563 00
         133.575 00          133.575 00          148.058 00          148.058 00


              U*                   U*                  U*                   U*
           8.653 06           59.660 09            2.966 06           20.450 09
           9.412 06           64.899 09            2.232 06           15.388 09
           2.067 06           14.252 09          482.872 03            3.329 09
           2.459 06           16.956 09          799.304 03            5.511 09
           3.097 06           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		ALUMINUM	
	SI	ENGLISH	SI	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	-29.978-09
	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	-29.978-09
	3.478-06	608.696-06	37.681-12	259.812-09
INPUT	X	X	X	X
	1.400 09	203.046 03	400.000 06	[illegible]
	235.000 06	34.083 03	400.000 06	[illegible]
	12.000 06	1.740 03	400.000 06	[illegible]
	53.000 06	7.687 03	400.000 06	[illegible]
	34.000 06	4.931 03	230.000 06	[illegible]
	FXY	FXY	FXY	FXY
	-500.000-03	-500.000-03	-500.000-03	-500.000-03
	F	F	F	F
	3.040-18	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	-148.566-12
	865.052-18	41.125-09	18.904-18	898.596-12
	-3.541-09	-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	-149.922 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	609.397 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

$$\begin{tikzcd}
\boxed{E_x, \ldots h_o \; (25\text{-}28, 59)} \arrow[r, "\text{Eq. 1.12}"] & \boxed{Q \quad (10\text{-}15)} \arrow[r, "\text{Eq. 3.15}"] & \boxed{U \quad (30\text{-}34)}
\end{tikzcd}$$

$$\begin{tikzcd}
\boxed{X, \ldots F^*_{xy} \; (25\text{-}28)} \arrow[r, "\text{Eq. 7.11}"] & \boxed{F \quad (44\text{-}49)} \arrow[r, "\text{Eq. 7.28}"] & \boxed{G \quad (44\text{-}49)}
\end{tikzcd}$$

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 $\boxed{3}$ $\boxed{\text{2nd}}$ $\boxed{\text{Write}}$ 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

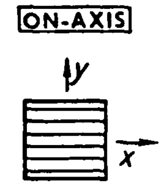
```
240  05  5
241  94  +/-
242  42  STO
243  28  28
244  71  SBR
245  45  YX
-----------------
246  76  LBL
247  16  A'
248  47  CMS
249  57  ENG
250  [illegible]      Aℓ
251  [illegible]
252  52  EE
253  [illegible]
254  42  STO
255  [illegible]
256  42  STO
257  [illegible]
258  [illegible]
259  [illegible]
260  [illegible]
261  [illegible]
262  [illegible]
263  42  STO
264  [illegible]
265  [illegible]
266  [illegible]
267  42  STO
268  [illegible]
269  01  1
270  42  STO
271  59  59
272  71  SBR
273  35  1/X
274  04  4
275  52  EE
276  08  8
277  42  STO
278  23  23
279  42  STO
280  24  24
281  42  STO
282  25  25
283  42  STO
284  26  26
285  [illegible]
286  [illegible]
287  52  EE
288  [illegible]
289  42  STO
290  [illegible]
291  [illegible]
292  [illegible]
293  [illegible]
294  42  STO
295  [illegible]
296  71  SBR
297  45  YX
-----------------
298  76  LBL
299  10  E'
```

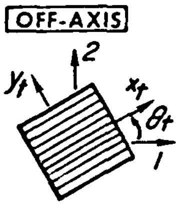
```
300  06  6
301  08  8      SI →
302  09  9      Engl.
303  05  5
304  35  1/X
305  49  PRD
306  30  30
307  49  PRD
308  31  31
309  49  PRD
310  32  32
311  49  PRD
312  33  33
313  49  PRD
314  34  34
315  95  =
316  03  3
317  09  9
318  93  .
319  04  4
320  49  PRD
321  [illegible]
322  [illegible]
-----------------
323  76  LBL
324  12  B
325  47  CMS
326  57  ENG
327  03  3      B(4)/
328  00  0      5505
329  04  4
330  52  EE
331  [illegible]
332  42  STO
333  25  25
334  01  1
335  08  8
336  93  .
337  05  5
338  52  EE
339  [illegible]
340  42  STO
341  26  26
342  93  .
343  02  2
344  03  3
345  42  STO
346  28  28
347  05  5
348  93  .
349  05  5
350  09  9
351  52  EE
352  [illegible]
353  42  STO
354  [illegible]
355  01  1
356  [illegible]
357  05  5
358  52  EE
359  06  6
```

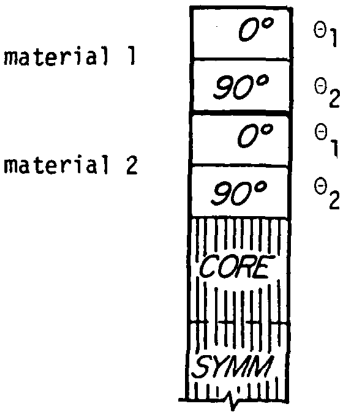
```
360  94  +/-
361  42  STO
362  59  59
363  71  SBR
364  35  1/X
365  01  1
366  02  2
367  06  6
368  52  EE
369  07  7
370  42  STO
371  23  23
372  03  3
373  05  5
374  52  EE
375  [illegible]
376  42  STO
377  24  24
378  06  6
379  01  1
380  52  EE
381  06  6
382  42  STO
383  25  25
384  [illegible]
385  00  0
386  02  2
387  52  EE
388  06  6
389  42  STO
390  26  26
391  06  6
392  07  7
393  52  EE
394  06  6
395  42  STO
396  [illegible]
397  93  .
398  05  5
399  94  +/-
400  42  STO
401  28  28
402  71  SBR
403  45  YX
-----------------
404  76  LBL
405  15  E
406  47  CMS
407  57  ENG
408  07  7      Kevlar
409  06  6      49/
410  52  EE     Epoxy
411  09  9
412  42  STO
413  [illegible]
414  [illegible]
415  05  5
416  52  EE
417  08  8
418  42  STO
419  26  26
```

```
420  02  2
421  03  3
422  52  EE
423  08  8
424  42  STO
425  27  27
426  93  .
427  03  3
428  04  4
429  42  STO
430  28  28
431  01  1
432  02  2
433  05  5
434  52  EE
435  06  6
436  94  +/-
437  42  STO
438  59  59
439  71  SBR
440  35  1/X
441  01  1
442  04  4
443  52  EE
444  08  8
445  42  STO
446  23  23
447  02  2
448  03  3
449  05  5
450  52  EE
451  [illegible]
452  42  STO
453  [illegible]
454  [illegible]
455  [illegible]
456  52  EE
457  06  6
458  42  STO
459  25  25
460  05  5
461  03  3
462  52  EE
463  06  6
464  42  STO
465  26  26
466  [illegible]
467  04  4
468  52  EE
469  06  6
470  42  STO
471  [illegible]
472  93  .
473  05  5
474  94  +/-
475  42  STO
476  28  28
477  71  SBR
478  45  YX
479  00  0
```

NOTES



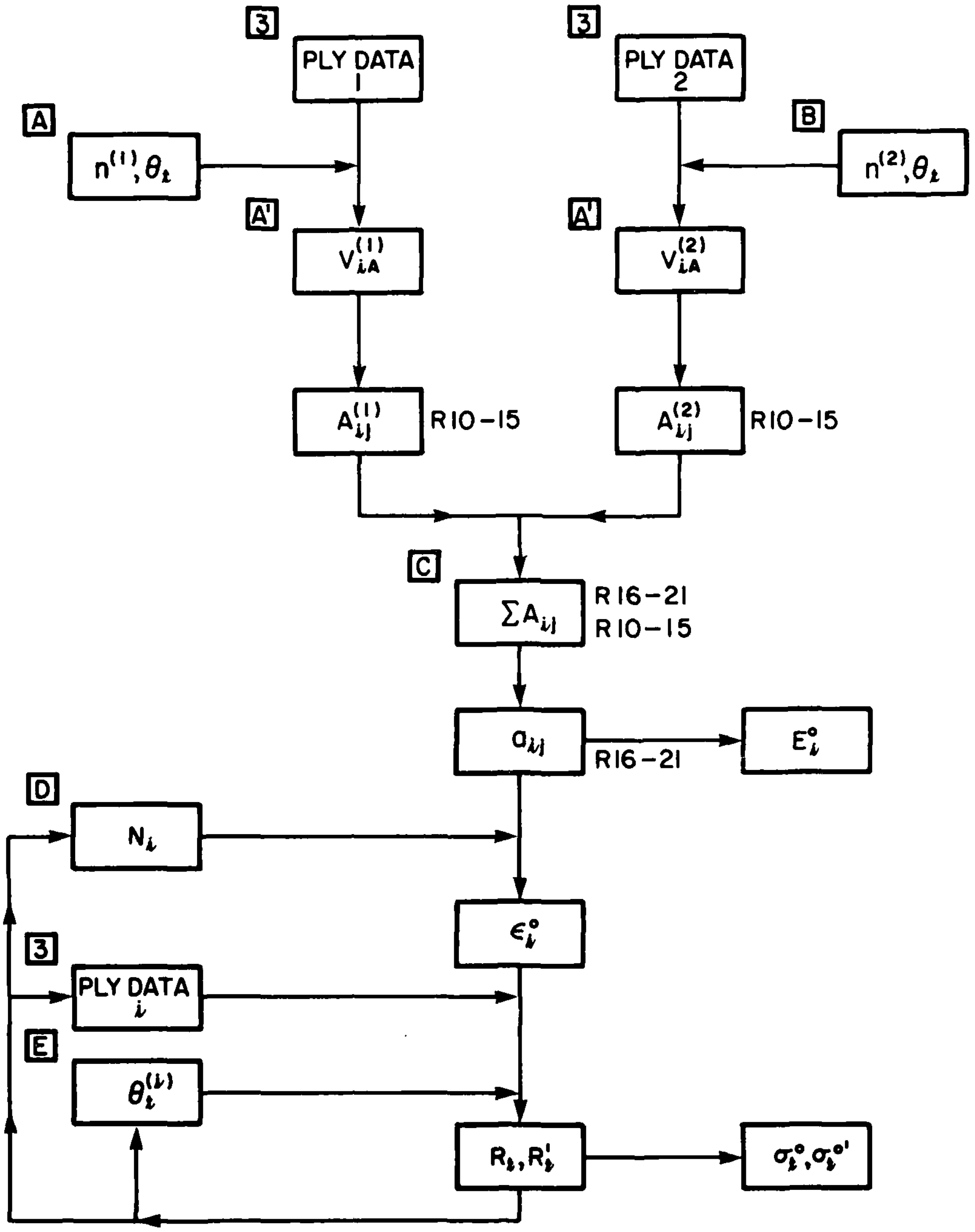




$[0^{(1)}/90^{(1)}/0^{(2)}/90^{(2)}/C_2]_s$

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_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 #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}	C	A	A_{11}, A_{22}, A_{12}, A_{66}, A_{16}, A_{26}	
	E_i°, A_{ij}^*			a_{11}, a_{22}, a_{12}, a_{66}, a_{16}, a_{26}	
			E*	E_1°, E_2°, ν_{21}°, E_6°	
			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			when prompter = c	
	(see note 2)	A'	CR	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
098  61  GTO   Via
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)

```
240  43 RCL
241  16  16
242  95  =      Ei°
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     N1
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  03  3     —
327  95  =
328  91 R/S
329  99 PRT
330  42 STO    N2
331  27  27
332  06  6
333  93  .
334  06  6
335  95  =
336  91 R/S
337  99 PRT
338  42 STO    N6
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    Ei°
348  89  π
349  36 PGM
350  10  10
351  71 SBR
352  24 CE     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     ↑Θ
366  00  0
367  95  =
368  91 R/S
-------------
369  76 LBL
370  15  E
371  42 STO
372  41  41    Θt
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  )     Ei(Θt')
426  00  0
427  42 STO
428  26  26    Ei^n=σ
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    Rt
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  =     σt°
462  99 PRT
463  43 RCL
464  07  07
465  55  ÷
466  43 RCL
467  09  09    σt°'
468  95  =
469  99 PRT
470  98 ADV
471  91 R/S    —
-------------
472  76 LBL
473  23 LNX
474  55  ÷     →Aij
475  [illegible]
476  [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] 06 [illegible] 06 [illegible] 06 [illegible] 06 0.000 00 [illegible] 00
PRINT a_{ij}		[illegible] [illegible] [illegible] [illegible] [illegible] 00 0.000 00
PRINT E_i°		E– [illegible]4.841 09 24.689 09 102.[illegible]-0[illegible] 5.[illegible]55 09
PRINT A_{ij}^*		F– [illegible]5.[illegible]01 09 14.[illegible]57 09 2.[illegible] 09 5.[illegible]55 09 0.[illegible]00 00 0.000 00

PROCEDURE	KEY	PRINT
ENTER N_1 N_2 N_6	D	N 1.[illegible] [illegible] [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]57 0[illegible] [illegible] 557.314 06 1.257 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
Enter $n^{(1)}$	A	[illegible]
Enter θ_1 θ_2	R/S R/S	[illegible]
Enter $n^{(2)}$	B	[illegible]
Enter θ_1	R/S	[illegible]
PRINT A_{ij}	C	[illegible]
PRINT a_{ij}		[illegible]
PRINT E_i^o		[illegible]
PRINT A_{ij}^*		[illegible]

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] 4[illegible].382 06 1.772 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: $[90^{(1)}/0^{(2)}]_s$ **MATERIAL 1:** T300/5208 **MATERIAL 2:** Scotchply 1002

PROCEDURE	KEY	PRINT	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	θ 90.000 00
Enter $n^{(1)}$	A	n1 1.000 00	PRINT R_t R_t' σ^o $\sigma^{o\prime}$		F+I 48.000 03 241.517 03 35.599 06 585.034 06
Enter Θ_1	R/S	90.000 00 θ1			
Enter $n^{(2)}$	B	n2 1.000 00	ENTER Θ_t[1]	E	θ 0.000 00
Enter Θ_1	R/S	0.000 00 θ1	PRINT R_t R_t' σ^o $\sigma^{o\prime}$		F+I 230.498 03 360.794 03 460.996 06 720.187 06
PRINT A_{ij}	C	A 12.379 06 47.551 06 1.270 06 1.827 06 0.000 00 0.000 00			
PRINT a_{ij}		81.705-09 21.368-09 -1.161-09 351.669-09 0.000 00 0.000 00			
PRINT E_i^o		E- 24.159 09 44.841 09 36.702-03 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			

---

[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 -540.762-12 18.417-09 0.000 00 0.000 00
PRINT E_i^o		E. 54.741 09 32.419 09 102.577-03 5.655 09
PRINT A_{ij}^*		A* 95.101 09 24.757 09 2.539 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 714.608 03 2.714 06 257.714 06 [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: $[0_2^{(1)}/90_2^{(2)}/c_2]_s$ MATERIAL 1: T300/5208 MATERIAL 2: Scotchply 1002

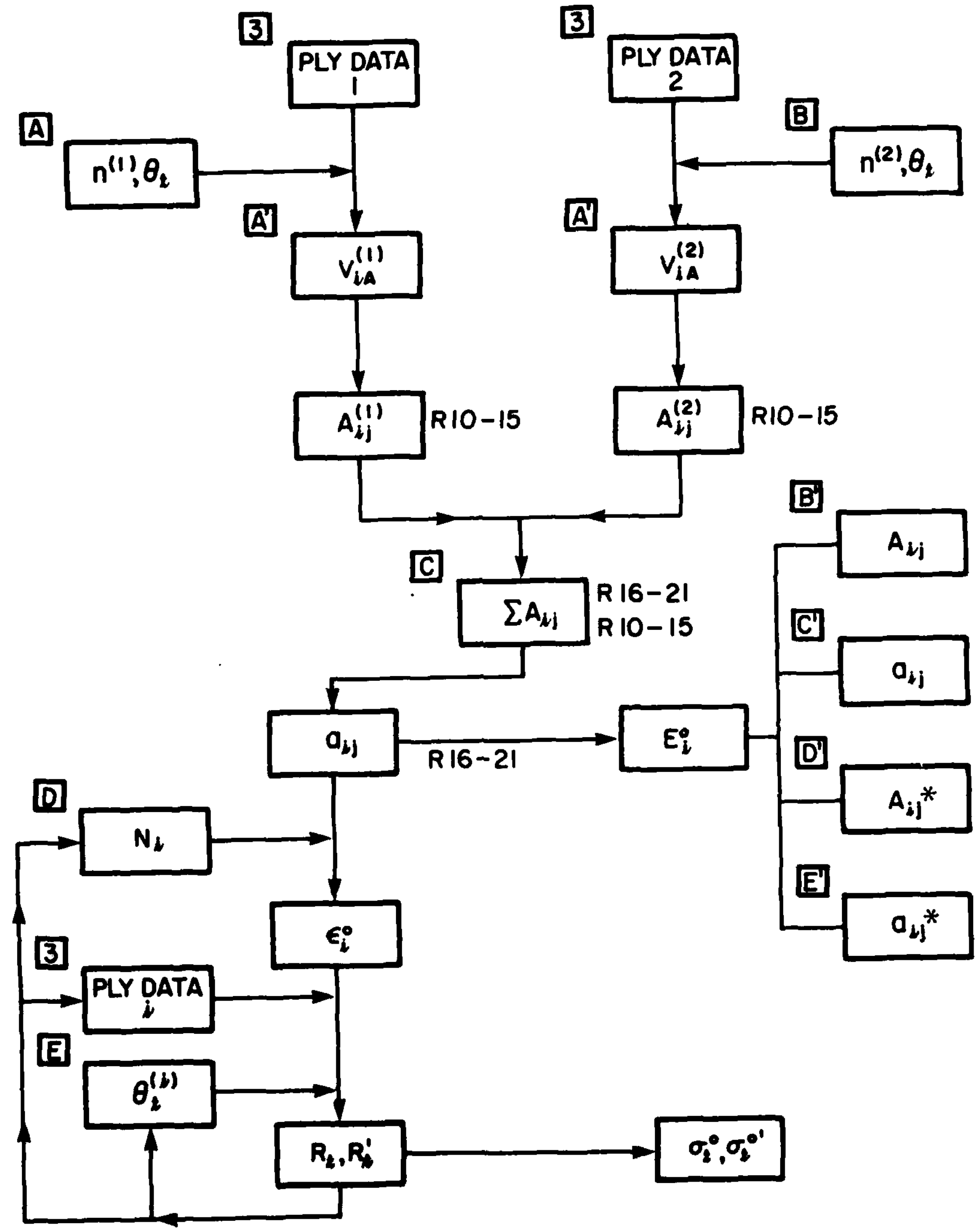
PROCEDURE	KEY	PRINT
Enter $n^{(1)}$	A	[illegible]
Enter θ_1 Enter θ_2	R/S R/S	[illegible]
Enter $n^{(2)}$	B	[illegible]
Enter θ_1 θ_2	R/S R/S A'	[illegible]
PRINT A_{ij}	C	[illegible]
PRINT a_{ij}		10.544-09 40.504-09 -1.052-09 176.835-09 0.000 00 0.000 00
PRINT E_i^o		E* 53.227 09 16.459 09 100.570-03 3.770 09
PRINT A_{ij}^*		A* [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^o $\sigma^{o\prime}$		[illegible]
ENTER Θ_t[1]	E	[illegible]
PRINT R_t R_t' σ^o $\sigma^{o\prime}$		[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' core	B' A_{ij}	C' a_{ij}	D' A^*_{ij}	E' a^*_{ij}
A material 1 $n^{(1)}, \Theta_t^{(1)}$	B material i $n^{(i)}, \Theta_t^{(i)}$	C E°_i	D $N_i \rightarrow \epsilon^\circ_i$	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/S R/S R/S R/S	R_t R'_t σ^o_t $\sigma^{o\prime}_t$ 60

OPTIONS

*	For sandwich construction (see note 2) continue with step 4	- A'	when prompter = c 0
**	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

```
[illegible]                 n(1)
[illegible]
                            n(i)
[illegible]                 h
040  49  PRD                n/2=
041  05   05
042  43  RCL                t
043  05   05
044  91  R/S
045  94  +/-
046  42  STO                Θt
047  35   35
048  01    1
049  42  STO
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
```

```
[illegible]                 C
[illegible]                 Via
[illegible]                 Aij(i)
[illegible]                 ΣAij(i)
[illegible]
100  91  R/S
101  76  LBL                n(2)
102  13   E
103  42  STO
104  05   05
105  00    0
106  36  PGM
107  12   12
108  71  SBR
109  61  GTO
110  71  SBR
111  35  1/X
112  76  LBL
113  13    C
114  43  RCL                Aij
115  16   16
116  42  STO
117  10   10
118  43  RCL
119  17   17
```

```
[illegible]                 Aij
[illegible]                 E_i^0
165  94  +/-
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    .                N1
176  01    1
177  95    =
178  91  R/S
179  76  LBL
```

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

COMBO 4 HYBRID: IN-PLANE

```
[illegible]
295  55  ÷
296  43  RCL
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
308  17  B'          Aij
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   .      Ei'(θt)
329  01   1
330  95  =
331  91  R/S    Ei^n-0
------------------
332  76  LBL
333  18  C'          Aij
334  43  RCL
335  16   16
336  91  R/S
337  43  RCL
338  17   17     Gij
339  91  R/S
340  43  RCL
341  18   18     Rt
342  91  R/S
343  43  RCL
344  19   19     R't
345  91  R/S
346  43  RCL
347  20   20
348  91  R/S
349  43  RCL
350  21   21
351  91  R/S     σt^o
352  06   6
353  93   .
354  01   1
355  95  =
356  91  R/S     σt^o'
------------------
357  76  LBL
358  19  D'          Aij•
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
407  10  E'          Aij+
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
```

*U.S.Government Printing Office: 1982 — 559-006/5089