Table 2.1

flat.shear.itype1.runstream

28 June, 2008

This is a monocoque aluminum flat plate under combined axial compression, Nx = -30 lb/in and uniform in-plane shear, Nxy = 300 lb/in. The plate is allowed to go into its postbuckled state.

The case is called "flat".

The runstream for optimization is:

```
panda2log       (activate PANDA2 commands)                                  Table 1.2
begin           (establish starting design; input data = flat.BEG)          Table 1.3
setup           (PANDA2 sets up matrix templates)
decide          (choose decision variables and bounds, etc. input = flat.DEC)
mainsetup       (choose loading, strategy, analysis type, etc.
                 cp flat.shear.itype1.opt flat.OPT; input=flat.OPT)         Table 2.2
pandaopt        (PANDA2 does computations)
pandaopt        (PANDA2 does computations)
pandaopt        (PANDA2 does computations)
cp flat.OPP flat.shear.opp                                                  Table 2.3
chooseplot      (choose what to plot.                                       Table 2.4
                 cp flat.shear.cpl flat.CPL; input = flat.CPL)
diplot          (obtain postscript files: flat.3.ps, flat.4.ps, flat.5.ps)
cp flat.3.ps flat.margins.shearload.ps                                      Fig. 2.1
cp flat.4.ps flat.thickness.shearload.ps                                    Fig. 2.2
cp flat.5.ps flat.objective.shearload.ps                                    Fig. 2.3
(edit flat.OPT to get results for "fixed" (optimized)
 design, that is, change ITYPE from 1 to 2)                                 Table 2.5
pandaopt
cp flat.OPM flat.opm and generate flat.axial.itype2.abridged.opm            Table 2.6
cleanpan        (clean up "flat" files)
-----------------------------------------------------------
```

The optimum thickness is t = 0.06026 inch.

NOTE: You have to include a small initial imperfection whenever the in-plane shear loading is dominant.

Table 2.2 flat.OPT (optimization)

```
        n        $ Do you want a tutorial session and tutorial output?
   -30.000       $ Resultant (e.g. lb/in) normal to the plane of screen, Nx( 1)
         0       $ Resultant (e.g. lb/in) in the plane of the screen,    Ny( 1)
    300.00       $ In-plane shear in load set A,                        Nxy( 1)
        n        $ Does the axial load vary in the L2 direction?
  0.000000       $ Applied axial moment resultant (e.g. in-lb/in), Mx( 1)
  0.000000       $ Applied hoop moment resultant (e.g. in-lb/in), My( 1)
        Y        $ Want to include effect of transverse shear deformation?
         0       $ IQUICK = quick analysis indicator (0 or 1)
        Y        $ Do you want to vary M for minimum local buckling load?
        N        $ Do you want to choose a starting M for local buckling?
        Y        $ Do you want to perform a "low-axial-wavenumber" search?
 0.2000000       $ Factor of safety for general instability, FSGEN( 1)
 0.2000000       $ Minimum load factor for local buckling (Type H for HELP), FSLOC( 1)
  1.000000       $ Minimum load factor for stiffener buckling (Type H), FSBSTR( 1)
  1.000000       $ Factor of safety for stress, FSSTR( 1)
        Y        $ Do you want "flat skin" discretized module for local buckling?
        N        $ Do you want wide-column buckling to constrain the design?
  0.000000       $ Resultant (e.g. lb/in) normal to the plane of screen, Nx0( 1)
  0.000000       $ Resultant (e.g. lb/in) in the plane of the screen,    Ny0( 1)
         0       $ Axial load applied along the (0=neutral plane), (1=panel skin)
  0.000000       $ Uniform applied pressure [positive upward. See H(elp)], p( 1)
  0.000000       $ Out-of-roundness, Wimpg1=(Max.diameter-Min.diam)/4, Wimpg1( 1)
note ->[ 0.010000       $ Initial buckling modal general imperfection amplitude, Wimpg2( 1)
        [ 0.0100000     $ Initial local imperfection amplitude (must be positive), Wloc( 1)
        Y        $ Do you want PANDA2 to change imperfection amplitudes (see H(elp))?( 1)
        50       $ Axial halfwavelength of typical general buckling mode, AXLWAV( 1)
        Y        $ Do you want PANDA2 to find the general imperfection shape?( 1)
  1.000000       $ Maximum allowable average axial strain (type H for HELP)( 1)
        N        $ Is there any thermal "loading" in this load set (Y/N)?
        Y        $ Do you want a "complete" analysis (type H for "Help")?
        N        $ Want to provide another load set ?
        N        $ Do you want to impose minimum TOTAL thickness of any segment?
        N        $ Do you want to impose maximum TOTAL thickness of any segment?
        N        $ Use reduced effective stiffness in panel skin (H(elp), Y or N)?
         0       $ NPRINT= output index (-1=min. 0=good, 1=ok, 2=more, 3=too much)
         0       $ Index for type of shell theory (0 or 1 or 2), ISAND
        Y        $ Does the postbuckling axial wavelength of local buckles change?
        Y        $ Want to suppress general buckling mode with many axial waves?
        N        $ Do you want to double-check PANDA-type eigenvalues [type (H)elp]?
         0       $ Choose (0=transverse inextensional; 1=transverse extensional)
         1       $ Choose ICONSV = -1 or 0 or 1 or H(elp), ICONSV
optimization ->  1       $ Choose type of analysis (ITYPE = 1 or 2 or 3 or 4 or 5)
        Y        $ Do you want to prevent secondary buckling (mode jumping)?
        N        $ Do you want to use the "alternative" buckling solution?
         5       $ How many design iterations permitted in this run (5 to 25)?
  1.000000       $ MAXMAR. Plot only those margins less than MAXMAR (Type H)
        N        $ Do you want to reset total iterations to zero (Type H)?
         1       $ Index for objective (1=min. weight, 2=min. distortion)
  1.000000       $ FMARG (Skip load case with min. margin greater than FMARG)
```

flat.shear.itype1.opt

Note that both local & general buckling are the same phenomenon because there are no stiffeners.

Table 2.3 (1 of 3) flat.OPP = flat.shear.opp

flat.shear.opp (29 June, 2008)

```
 ************ July 2007 VERSION OF PANDA2   ************
 ***************** THIS IS THE  flat.OPP FILE ******************

 ********************** STORE PROCESSOR **********************
 The purpose of STORE is to add the latest results for
 margins, design variables, and objective to those for previous
 iterations for the specific case called flat.  Later, when
 the final design has been obtained, the entire history of the
 design evolution for the specific case flat can be plotted.
 ************************************************************

  ITRTOT,NITER,ITRPLT,ITRLST = 10 1 10 9
  IAUTOC,ITIGHT,IDESGN= 0 0 2
  IITIGH(i),i=1,3= 0 0 0
  ITRMIN(i),i=1,3= 100000 100000 100000

 ****** DESIGN VARIABLES FOR  10 ITERATIONS ******

   1     T(1 )(SKN):thickness for layer index no.(1 ): SKN seg=1 , layer=1 =
  1.0000E-01  9.0000E-02  8.2800E-02  7.7501E-02  7.3533E-02  7.0521E-02  7.0521E-02  6.3469E-02»
  6.0260E-02  6.0260E-02

 ********** OBJECTIVE FOR  10 ITERATIONS *********

   1    WEIGHT OF THE ENTIRE PANEL =
  5.0000E+00  4.5000E+00  4.1400E+00  3.8750E+00  3.6766E+00  3.5260E+00  3.5260E+00  3.1734E+00»
  3.0130E+00  3.0130E+00

   1    Absolute values of maximum constraint gradients, GRDPLT =
  2.4996E+01  3.2442E+01  3.2950E+01  1.6673E+01  1.1324E+01  0.0000E+00  8.9299E+00  5.6678E+00»
  5.4789E+00  5.4789E+00

 ****** DESIGN MARGINS FOR  10 ITERATIONS ******
 ****** LOAD SET NO. 1                   ******
 ****** SUB-CASE (1=MIDLENGTH, 2=PANEL END)= 1 *****

   1   Local buckling: discrete model =
  6.9018E+00  4.7624E+00  3.4881E+00  2.6810E+00  2.1444E+00  1.7738E+00  1.7738E+00  1.0225E+00»
  7.3112E-01  7.3112E-01

   2   Local buckling: Koiter theory. =
  6.9122E+00  4.7693E+00  3.4932E+00  2.6849E+00  2.1476E+00  1.7766E+00  1.7766E+00  1.0243E+00»
  7.3269E-01  7.3269E-01

   3   eff.stress:matl=1; MID. =
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  9.7000E-01  9.7000E-01  2.8651E-01»
  7.1913E-03  7.1913E-03

   4   buck(DONL)simp-support general buck; MIDLENGTH =
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00»
  7.3865E-01  7.3865E-01

 ****** DESIGN MARGINS FOR  10 ITERATIONS ******
 ****** LOAD SET NO. 1                   ******
 ****** SUB-CASE (1=MIDLENGTH, 2=PANEL END)= 2 *****

   1   Local buckling: discrete model =
  6.9018E+00  4.7624E+00  3.4881E+00  2.6810E+00  2.1444E+00  1.7738E+00  1.7738E+00  1.0225E+00»
  7.3113E-01  7.3112E-01

   2   Local buckling: Koiter theory. =
  6.9122E+00  4.7693E+00  3.4932E+00  2.6849E+00  2.1476E+00  1.7766E+00  1.7766E+00  1.0243E+00»
  7.3269E-01  7.3269E-01

   3   eff.stress:matl=1; ENDS =
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  9.7000E-01  9.7000E-01  2.8651E-01»
  7.1913E-03  7.1913E-03

        SUMMARY OF STATE OF THE DESIGN WITH EACH ITERATION
 ==========================================================================================
 ITERA   WEIGHT                      FOR EACH LOAD SET....             ANY ABRUPT CHANGES IN MO»
DE?
 TION      OF                (IQUICK; NO. OF CRITICAL MARGINS)      SLOPE CHANGE? (m,n) CHAN»
GE?
 NO.     PANEL    LOAD SET NO.-> 1      2      3      4      5       EIG. RATIOS   EIG. RATI»
```

output from optimization

Table 2.3(2 of 3)

```
OS
                                                          LOAD SET NO.->   1   2   3    1   2   »
3
                                                           SUBCASE NO.-> 1 2 1 2 1 2  1 2 1 2 1»
 2
 ---------------------------------------------------------------------------------------------
 -----------------------------------------------------PANDAOPT
   1 5.0000E+00     FEASIBLE   (0; 0)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
   2 4.5000E+00     FEASIBLE   (0; 0)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
   3 4.1400E+00     FEASIBLE   (0; 0)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
   4 3.8750E+00     FEASIBLE   (0; 0)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
   5 3.6766E+00     FEASIBLE   (0; 0)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
   6 3.5260E+00     FEASIBLE   (0; 0)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
 -----------------------------------------------------PANDAOPT
   7 3.5260E+00     FEASIBLE   (0; 0)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
   8 3.1734E+00     FEASIBLE   (0; 0)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
   9 3.0130E+00     FEASIBLE   (0; 2)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
 -----------------------------------------------------PANDAOPT
  10 3.0130E+00     FEASIBLE   (0; 2)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0

 IOBJAL,ITRPLT=    0   10; OBJMN0,OBJPLT(ITRPLT)=  3.0130E+00  3.0130E+00
 ====================================================================================
0
  VALUES OF DESIGN VARIABLES CORRESPONDING TO BEST FEASIBLE DESIGN
 VAR. STR/ SEG. LAYER   CURRENT
 NO.  RNG  NO.   NO.     VALUE            DEFINITION
  1   SKN   1     1   6.026E-02    T(1 )(SKN):thickness for layer index no.(1 ): SKN seg=1 , lay»
er=1

 ***************************************************
 ******************** DESIGN OBJECTIVE *******************
 *************                            ***********
0
  CORRESPONDING VALUE OF THE OBJECTIVE FUNCTION:
 VAR. STR/ SEG. LAYER   CURRENT
 NO.  RNG  NO.   NO.     VALUE            DEFINITION
            0     0   3.013E+00   WEIGHT OF THE ENTIRE PANEL

 *************                         ************
 ******************** DESIGN OBJECTIVE *******************
 ***************************************************
 ITYPE,ITRTOT,ITRMX2,IAUTOC,ITIGHT,IITIGH(1),ITRMIN(1)=
       1      10     150       0       0       0  100000
 ITYPE,ITRTOT,ITRMX2,IAUTOC,ITIGHT,IITIGH(2),ITRMIN(1)=
       1      10     300       0       0       0  100000
 ITYPE,ITRTOT,ITRMX2,IAUTOC,ITIGHT,IITIGH(3),ITRMIN(2)=
       1      10     430       0       0       0  100000


 DESCRIPTION OF FILES USED AND GENERATED IN THIS RUN:

 flat.NAM = This file contains only the name of the case.
 flat.OPP = Output data. Please list this file and inspect
            carefully before proceeding.
 flat.CBL = Labelled common blocks for PANDA2 analysis.
            (This is an unformatted sequential file.)
 flat.PL1 = Binary file containing important results for plots
            from all design iterations except those correspond-
            ing to the final PANDAOPT command.
 flat.PL2 = Binary file containing important results for plots
            from all design iterations including those corres-
            ponding to the final PANDAOPT command.
 flat.PLD = Binary file containing all design parameters that
            are decision variable candidates and the objective
            function for all design iterations.
 flat.TIT = Binary file containing definitions of margins.
 flat.Pij = Binary files containing margins for all design
            iterations. i = subcase (1 or 2);  j = load set
```

Table 2.3 (3 of 3)

```
For further information about files used and generated
during operation of PANDA2, give the command HELPAN FILES.

Menu of commands: PANDAOPT, SUPEROPT, MAINSETUP, CHANGE,
                  DECIDE, CHOOSEPLOT, PANEL, STAGSMODEL
NOTE: IN ORDER TO AVOID FALSE CONVERGENCE OF THE DESIGN,
      BE SURE TO RUN  PANDAOPT  MANY TIMES DURING AN
      OPTIMIZATION.
****************** END OF THE  flat.OPP FILE *****************
```

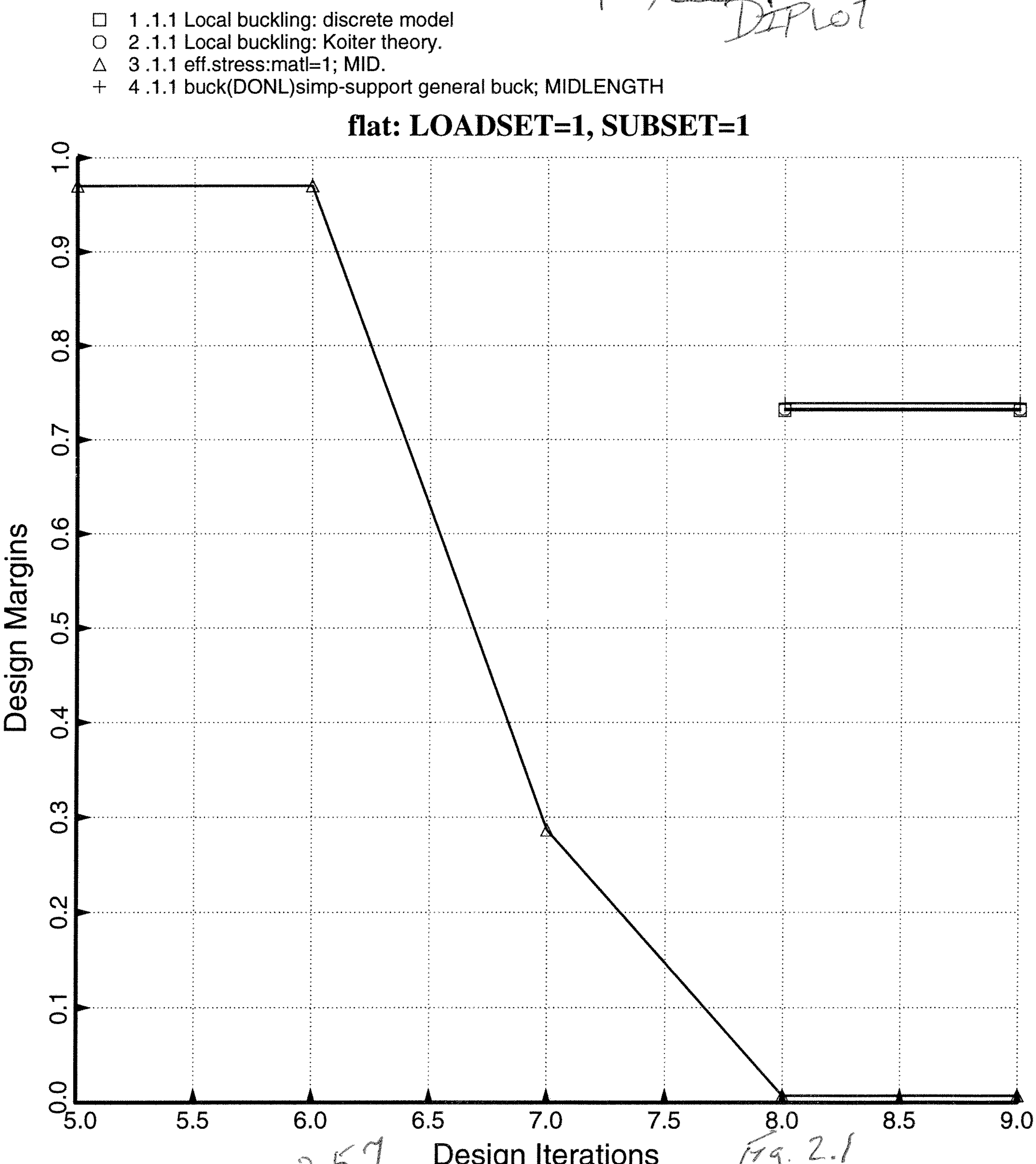
Table 2.4 flat.CPL (flat.shear.cpl)

```
n        $ Do you want a tutorial session and tutorial output?
y        $ Any design variables to be plotted v. iterations (Y or N)?
   1     $ Choose a variable to be plotted v. iterations (1,2,3,..)
n        $ Any more design variables to be plotted (Y or N) ?
y        $ Any design margins to be plotted (Y or N)?
   1     $ For which load set (1 - 5) do you want behavior/margins?
   1     $ Choose a sub-case (1 or 2) within this load set
   1     $ Choose a margin to be plotted v. iterations (1,2,3,..)
y        $ Any more margins to be plotted (Y or N) ?
   2     $ Choose a margin to be plotted v. iterations (1,2,3,..)
y        $ Any more margins to be plotted (Y or N) ?
   3     $ Choose a margin to be plotted v. iterations (1,2,3,..)
y        $ Any more margins to be plotted (Y or N) ?
   4     $ Choose a margin to be plotted v. iterations (1,2,3,..)
n        $ Any more margins to be plotted (Y or N) ?
   1     $ Give maximum value (positive) to be included in plot frame.
y        $ Do you want a plot of the objective v. iterations (Y/N)?
```

input for "CHOOSEPLOT"

flat.margins, shearload.ps

output, flat.3.ps from DIPLOT

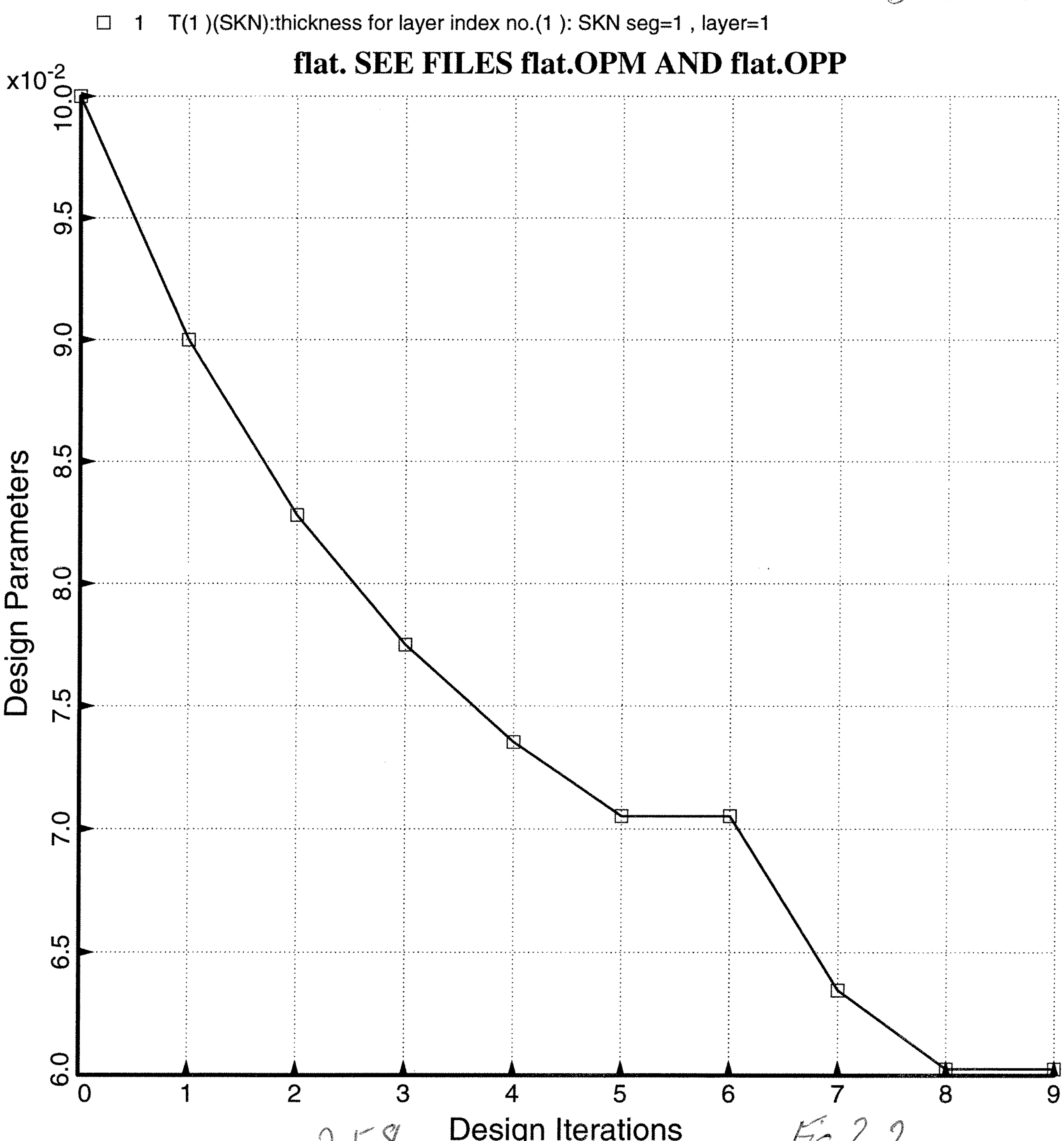


257

Fig. 2.1

flat.thickness.shearload.ps

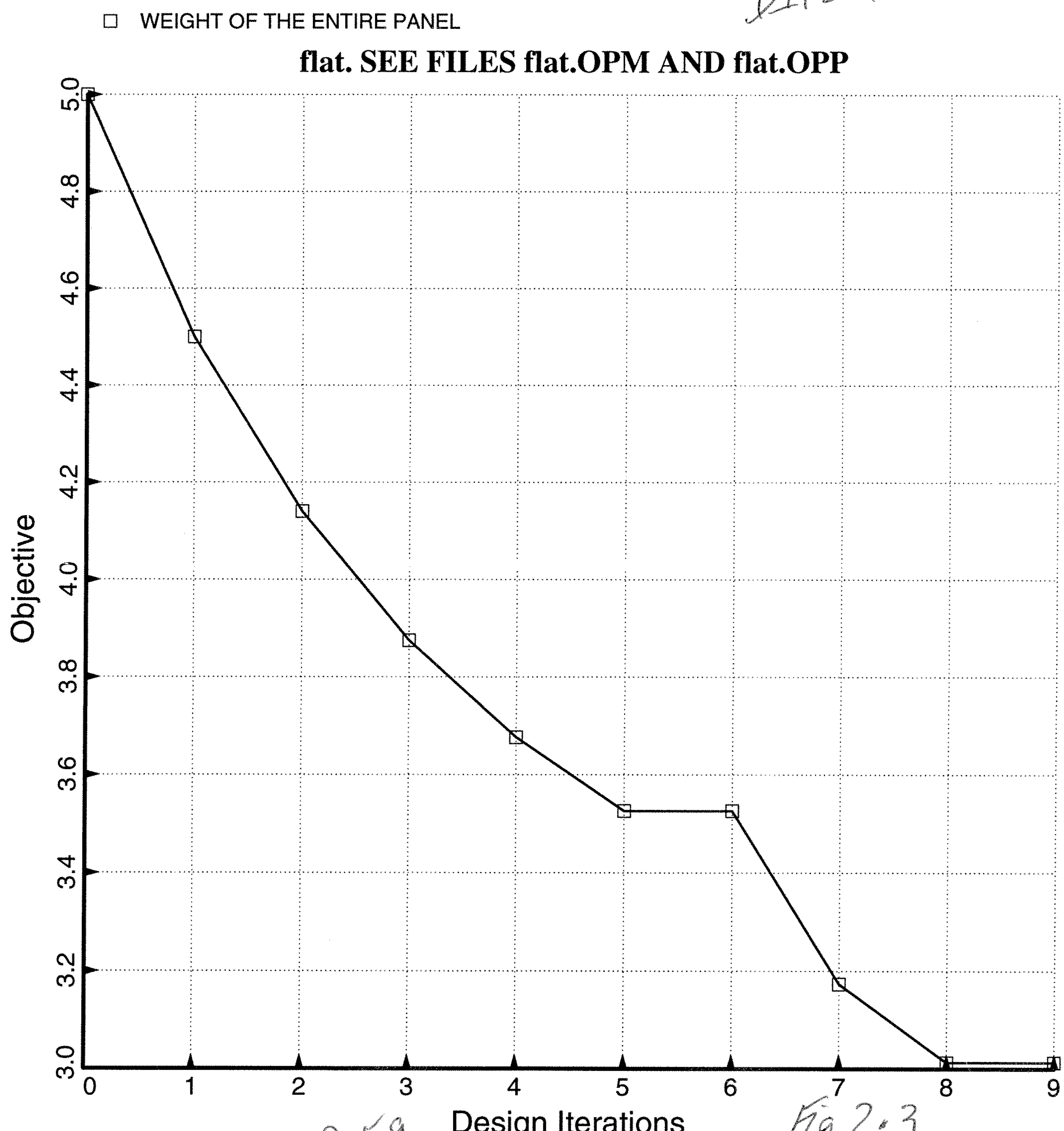
output, $\boxed{\text{flat.4.ps}}$, from DIPLOT



258

Fig. 2.2

flat.objective.shearload.ps
output, $\boxed{\text{flat.5.ps}}$ from
DIPLOT



259

Fig. 2.3

Table 2.5 Flat.OPT (flat.shear.itype2.opt)

```
     n          $ Do you want a tutorial session and tutorial output?
  -30.000       $ Resultant (e.g. lb/in) normal to the plane of screen, Nx( 1)
      0         $ Resultant (e.g. lb/in) in the plane of the screen,    Ny( 1)
   300.00       $ In-plane shear in load set A,                        Nxy( 1)
     n          $ Does the axial load vary in the L2 direction?
 0.000000       $ Applied axial moment resultant (e.g. in-lb/in), Mx( 1)
 0.000000       $ Applied hoop moment resultant (e.g. in-lb/in), My( 1)
     Y          $ Want to include effect of transverse shear deformation?
        0       $ IQUICK = quick analysis indicator (0 or 1)
     Y          $ Do you want to vary M for minimum local buckling load?
     N          $ Do you want to choose a starting M for local buckling?
     Y          $ Do you want to perform a "low-axial-wavenumber" search?
0.2000000       $ Factor of safety for general instability, FSGEN( 1)
0.2000000       $ Minimum load factor for local buckling (Type H for HELP), FSLOC( 1)
 1.000000       $ Minimum load factor for stiffener buckling (Type H), FSBSTR( 1)
 1.000000       $ Factor of safety for stress, FSSTR( 1)
     Y          $ Do you want "flat skin" discretized module for local buckling?
     N          $ Do you want wide-column buckling to constrain the design?
 0.000000       $ Resultant (e.g. lb/in) normal to the plane of screen, Nx0( 1)
 0.000000       $ Resultant (e.g. lb/in) in the plane of the screen,    Ny0( 1)
        0       $ Axial load applied along the (0=neutral plane), (1=panel skin)
 0.000000       $ Uniform applied pressure [positive upward. See H(elp)], p( 1)
 0.000000       $ Out-of-roundness, Wimpg1=(Max.diameter-Min.diam)/4, Wimpg1( 1)
 0.010000       $ Initial buckling modal general imperfection amplitude, Wimpg2( 1)
 0.010000       $ Initial local imperfection amplitude (must be positive), Wloc( 1)
     Y          $ Do you want PANDA2 to change imperfection amplitudes (see H(elp))?( 1)
       50       $ Axial halfwavelength of typical general buckling mode, AXLWAV( 1)
     Y          $ Do you want PANDA2 to find the general imperfection shape?( 1)
 1.000000       $ Maximum allowable average axial strain (type H for HELP)( 1)
     N          $ Is there any thermal "loading" in this load set (Y/N)?
     Y          $ Do you want a "complete" analysis (type H for "Help")?
     N          $ Want to provide another load set ?
     N          $ Do you want to impose minimum TOTAL thickness of any segment?
     N          $ Do you want to impose maximum TOTAL thickness of any segment?
     N          $ Use reduced effective stiffness in panel skin (H(elp), Y or N)?
note  -->  2    $ NPRINT= output index (-1=min. 0=good, 1=ok, 2=more, 3=too much)
        0       $ Index for type of shell theory (0 or 1 or 2), ISAND
     Y          $ Does the postbuckling axial wavelength of local buckles change?
     Y          $ Want to suppress general buckling mode with many axial waves?
     N          $ Do you want to double-check PANDA-type eigenvalues [type (H)elp]?
        0       $ Choose (0=transverse inextensional; 1=transverse extensional)
        1       $ Choose ICONSV = -1 or 0 or 1 or H(elp), ICONSV
note  -->  2    $ Choose type of analysis (ITYPE = 1 or 2 or 3 or 4 or 5)
     Y          $ Do you want to prevent secondary buckling (mode jumping)?
     N          $ Do you want to use the "alternative" buckling solution?
        5       $ How many design iterations permitted in this run (5 to 25)?
 1.000000       $ MAXMAR. Plot only those margins less than MAXMAR (Type H)
     N          $ Do you want to reset total iterations to zero (Type H)?
        1       $ Index for objective (1=min. weight, 2=min. distortion)
 1.000000       $ FMARG (Skip load case with min. margin greater than FMARG)
```

input for MAINSETUP for fixed design

Table 2.6

Abridged output from PANDAOPT (flat.OPM file abridged)

```
flat.shear.itype2.abridged.opm

abridged flat.OPM file corresponding to combined
 Nx = -30, Nxy = 300 lb/in optimized plate

 ************************************************************
 CHAPTER 26 Compute local, inter-ring, general buckling load
            factors from PANDA-type models [1B] and from
            "alternative" (double-trigonometric series
            expansion) models, Ref.[1G]. Also compute
            sandwich wall behavior [1F], if applicable.

*** BEGIN SUBROUTINE BUCPAN (PANDA-TYPE BUCKLING LOADS) ****

 Number of constraints, NCONST=       0

  LABEL NO. IN STRUCT= 9260
 ******* ENTERING BUCPAN FROM STRUCT OR STRIMP:
 ILABEL,IPRELM,IGENRL,IGENX,    EIGMAX=
  9260     0     0     0  1.0000E+07

 general buckling: smeared stiffeners, C11=  6.6220E+05, radius, R=  5.0990E+05
 ******** ENTERING GENSTB: PANDA-type buckling model ********
 PANDA-type buckling theory is described in the journal paper:
 D. Bushnell, "Theoretical basis of the PANDA computer program"
 Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
 Also see Items 415 and 443 in ...panda2/doc/panda2.news.
 ILABEL = unique "CALL GENSTB" within SUBROUTINE BUCPAN
 ILABLY = label number near where SUBROUTINE BUCPAN is called.
   ILABEL, ILABLY, IDESGN,  ISAND,    INDX,    ITHRU,  IROLL    IFFLAT =
    7195     9260      0        0        2        1       0       1
  Radius  R,   Axial length, A,   Width  B
  5.099020E+05  5.000000E+01  1.000000E+01
 Initial imperfections for general, panel, local buckling=
 Total out-of-roundness + modal,     W0GLOB =  1.0000E-02
 Out-of-roundness,                     WG1  =  0.0000E+00
 General buckling modal,               WG2  =  1.0000E-02
 Inter-ring buckling modal,          W0PAN =  1.0000E-02
 Local buckling modal,               W0LOC =  1.0000E-02
 ***** NOTE: Panel is modelled as if it were flat. *****
 ***** Donnell theory is used in this section (ISAND=0)
 Load Set A: Nx,  Ny,  Nxy= -3.0000E+01  0.0000E+00  3.0000E+02
 Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00
 Membrane stiffnesses ((C(i,j),j=1,3),i=1,3)=
  6.6220E+05  1.9866E+05  0.0000E+00
  1.9866E+05  6.6220E+05  0.0000E+00
  0.0000E+00  0.0000E+00  2.3177E+05
      R/B,       C44MLT,       C44N,       C55N,       FFLAT=
  1.0000E+04  1.0000E+00  3.0261E-04  3.0261E-04  1.0000E+00
 Test for direction panel is long: TEST=(A/B)*SQRT(C55N/(C44N*C44MLT))=5.00E+00
 If TEST > 0.99 then d = 0;  c = SLOPE (panel is long in x-direction, Fig.(9a).
 If TEST < 0.99 then d = SLOPE; c = 0. (panel is long in y-direction, Fig.(9b).
 See Eq.(51) and Fig. 9 of "Theoretical basis..." paper (1987).
 ***(low-n)***
 (high-m) mode:ICHEK ISAND  m    n      s      EIGENVALUE  TEST
                0     0    4    1  6.811E-01  3.479E-01  5.000E+00
 Ratio needed in ARBOCZ: EIGTST/EIGTS2= EIGRAT=  1.0000E+00

 EIGMNC=  4.68E-01  1.00E+17  3.48E-01  1.00E+17  1.00E+17  8.36E-01  1.00E+17
 SLOPEX=  9.81E-01  0.00E+00  6.81E-01  0.00E+00  0.00E+00  2.03E+00  0.00E+00
 MWAVEX=     2         0         4         0         0         1         0
 NWAVEX=     1         0         1         0         0         1         0
 TESTX =  5.00E+00  0.00E+00  5.00E+00  0.00E+00  0.00E+00  5.00E+00  0.00E+00
 Before refinement (before CALL EIG), EIGVAL,CSLOPE=  3.4795E-01   6.8109E-01
  After refinement ( after CALL EIG), EIGVAL,CSLOPE=  3.4792E-01   6.6774E-01

(many, many lines skipped to save space)

 CHAPTER 28 Present design, loading, and margins for the
           current load set and subcase. See Table 6 in
 Bushnell, D.
 "Optimization of an axially compressed ring and stringer
 stiffened cylindrical shell with a general buckling modal
 imperfection", AIAA Paper 2007-2216, 48th AIAA SDM Meeting,
 Honolulu, Hawaii, April 2007
0
          SUMMARY OF INFORMATION FROM OPTIMIZATION ANALYSIS
 VAR. DEC. ESCAPE LINK. LINKED  LINKING   LOWER    CURRENT    UPPER       DEFINITION
```

compare with STAGS prediction Figs 2.12 & 2.13

4 axial halfwaves

Table 2.6 (end)

```
 NO. VAR.  VAR.  VAR.    TO   CONSTANT   BOUND     VALUE     BOUND
  1   Y     Y     N      0    0.00E+00  1.00E-02 6.0260E-02  1.00E+00    T(1 )(SKN):thickness f»
or layer index no.(1 ): SKN seg=1
 BUCKLING LOAD FACTORS FOR LOCAL BUCKLING FROM KOITER v. BOSOR4 THEORY:
  Local buckling load factor from KOITER theory = 3.4654E-01 (flat skin)
  Local buckling load factor from BOSOR4 theory = 3.4623E-01 (flat skin)

 *********** LOAD SET NO. 1  **************
 ICASE =  1  (ICASE=1 MEANS PANEL MIDLENGTH)
             (ICASE=2 MEANS PANEL ENDS                      )

   APPLIED LOADS IN LOAD SET A ("eigenvalue" loads):
         Applied     axial       stress resultant, Nx= -3.0000E+01
         Applied circumferential stress resultant, Ny=  0.0000E+00
         Applied    in-plane     shear  resultant,Nxy=  3.0000E+02
         Applied     axial       moment resultant, Mx=  0.0000E+00
         Applied circumferential moment resultant, My=  0.0000E+00
         Applied pressure (positive for upward),   p =  0.0000E+00

   APPLIED LOADS IN LOAD SET B ( fixed uniform loads):
         Applied     axial       stress resultant,Nx0=  0.0000E+00
         Applied circumferential stress resultant,Ny0=  0.0000E+00
         Applied    in-plane    shear  resultant,Nxy0=  0.0000E+00

 NOTE: "F.S." means "Factor of Safety";
 "DONL" means "Donnell shell theory used.";
 "SAND" means "Sanders shell theory used." panda2.news ITEM 128
 "Dseg" means "Segment numbering used in discretized model"
 "Iseg" means "Segment numbering used for input data." ITEM 272
0
 MARGINS FOR CURRENT DESIGN: LOAD CASE NO. 1, SUBCASE NO. 1
 MAR. MARGIN
 NO.  VALUE                 DEFINITION
 1  7.31E-01 Local buckling from discrete model-1.,M=5   axial halfwaves;FS=0.2
 2  7.33E-01 Local buckling from Koiter theory,M=4   axial halfwaves;FS=0.2
 3  7.19E-03 eff.stress:matl=1,SKN,Dseg=2,node=1,layer=1,z=0.0301; MID.;FS=1.
 4  3.32E+00 eff.stress:matl=1,SKN,Iseg=1,allnode,layer=1,z=-0.0301;-MID.;FS=1.
 5  7.39E-01 buck.(DONL);simp-support general buck;M=4;N=1;slope=0.6677;FS=0.2
 6  4.72E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
 7  7.39E-01 buck.(SAND);simp-support general buck;M=4;N=1;slope=0.6677;FS=0.2
```

Compare with STAGS (Fig. 2.12)
$\lambda_{STAGS} = 0.34059$

the only critical margin

Table 2.7

flat.shear.itype3.runstream

25 June, 2008

RUNSTREAM FOR ITYPE=3 ANALYSIS OF FIXED (OPTIMUM DESIGN)

NAME OF CASE = "flat"

```
LOADING = combined axial compression, Nx, and in-plane shear, Nxy:
                Nx =-1.5,  -3.0, -4.5, -6.0, -7.5,..., -30.0 lb/in
               Nxy = 15.0, 30.0, 45.0, 60.0, 75.0,..., 300.0 lb/in
```

Runstream follows:

```
panda2log        (activate PANDA2 commands)                          Table 1.2
begin            (establish starting design. Input = flat.BEG)       Table 2.8
change           (change thickness to optimum.
                   cp flat.shear.chg flat.CHG; Input=flat.CHG)
setup            (PANDA2 sets up matrix templates)                   Table 1.3
decide           (choose decision variables and bounds. Input=flat.DEC)
mainsetup        (choose loading, strategy, analysis type, etc.      Table 2.9
                   cp flat.shear.itype3.opt flat.OPT Input = flat.OPT)
pandaopt         (PANDA2 performs ITYPE=3 analysis. Input=flat.OPT)
chooseplot       (choose what to plot. Input = flat.CPL = flat.cpl31)  Table 2.10
diplot           (PANDA2 gets postscript plot files, flat.3.ps, flat.4.ps,  Figs. 2.4–2.10
                  flat.5.ps, flat.7.ps, flat.8.ps, flat.9.ps, flat.10.ps)
chooseplot       (choose what to plot. Input = flat.CPL = flat.cpl32)  Table ~~2.10~~ 2.11
diplot           (PANDA2 gets postscript plot file, flat.4.ps)         Fig. 2.11
cleanpan         (PANDA2 cleans up files, saving only the input files)
```

test simulation of optimized panel.
($t_{optimum}$ = 0.06026 inch)

"test simulation" = ITYPE=3 analysis type.
= Analysis of the optimized panel under increasing load.

Table 2.8 Flat.CHG (for case with shear)

```
n             $ Do you want a tutorial session and tutorial output?
y             $ Do you want to change any values in Parameter Set No. 1?
    1         $ Number of parameter to change (1, 2, 3, . . .)
0.602600E-01  $ New value of the parameter
n             $ Want to change any other parameters in this set?
n             $ Do you want to change values of "fixed" parameters?
n             $ Do you want to change values of allowables?
```

value from the optimization

Table 2.9 flat.OPT (for shear case) ITYPE=3

```
        n          $ Do you want a tutorial session and tutorial output?
note→[-1.5000      $ Resultant (e.g. lb/in) normal to the plane of screen, Nx( 1)
        0          $ Resultant (e.g. lb/in) in the plane of the screen,    Ny( 1)
     15.0          $ In-plane shear in load set A,                 Nxy( 1)
        n          $ Does the axial load vary in the L2 direction?
 0.000000          $ Applied axial moment resultant (e.g. in-lb/in), Mx( 1)
 0.000000          $ Applied hoop moment resultant (e.g. in-lb/in), My( 1)
        Y          $ Want to include effect of transverse shear deformation?
        0          $ IQUICK = quick analysis indicator (0 or 1)
        Y          $ Do you want to vary M for minimum local buckling load?
        N          $ Do you want to choose a starting M for local buckling?
        Y          $ Do you want to perform a "low-axial-wavenumber" search?
0.2000000          $ Factor of safety for general instability, FSGEN( 1)
0.2000000          $ Minimum load factor for local buckling (Type H for HELP), FSLOC( 1)
 1.000000          $ Minimum load factor for stiffener buckling (Type H), FSBSTR( 1)
 1.000000          $ Factor of safety for stress, FSSTR( 1)
        Y          $ Do you want "flat skin" discretized module for local buckling?
        N          $ Do you want wide-column buckling to constrain the design?
 0.000000          $ Resultant (e.g. lb/in) normal to the plane of screen, Nx0( 1)
 0.000000          $ Resultant (e.g. lb/in) in the plane of the screen,    Ny0( 1)
        0          $ Axial load applied along the (0=neutral plane), (1=panel skin)
 0.000000          $ Uniform applied pressure [positive upward. See H(elp)], p( 1)
 0.000000          $ Out-of-roundness, Wimpg1=(Max.diameter-Min.diam)/4, Wimpg1( 1)
note→[0.010000     $ Initial buckling modal general imperfection amplitude, Wimpg2( 1)
 0.010000          $ Initial local imperfection amplitude (must be positive), Wloc( 1)
        Y          $ Do you want PANDA2 to change imperfection amplitudes (see H(elp))?( 1)
       50          $ Axial halfwavelength of typical general buckling mode, AXLWAV( 1)
        Y          $ Do you want PANDA2 to find the general imperfection shape?( 1)
 1.000000          $ Maximum allowable average axial strain (type H for HELP)( 1)
        N          $ Is there any thermal "loading" in this load set (Y/N)?
        Y          $ Do you want a "complete" analysis (type H for "Help")?
        N          $ Want to provide another load set ?
        N          $ Do you want to impose minimum TOTAL thickness of any segment?
        N          $ Do you want to impose maximum TOTAL thickness of any segment?
        N          $ Use reduced effective stiffness in panel skin (H(elp), Y or N)?
        0          $ NPRINT= output index (-1=min. 0=good, 1=ok, 2=more, 3=too much)
        0          $ Index for type of shell theory (0 or 1 or 2), ISAND
        Y          $ Does the postbuckling axial wavelength of local buckles change?
        Y          $ Want to suppress general buckling mode with many axial waves?
        N          $ Do you want to double-check PANDA-type eigenvalues [type (H)elp]?
        0          $ Choose (0=transverse inextensional; 1=transverse extensional)
        1          $ Choose ICONSV = -1 or 0 or 1 or H(elp), ICONSV
note →  3          $ Choose type of analysis (ITYPE = 1 or 2 or 3 or 4 or 5)
        Y          $ Do you want to prevent secondary buckling (mode jumping)?
        n          $ Do you want to use the "alternative" buckling solution?
        1          $ Choose one of the load sets:  ILOAD
        1          $ Choose one of the sub cases (1  or  2):  ICASE
note→[-1.500000    $ Increment in axial resultant Nx:  DNX
        0          $ Increment in hoop resultant Ny:  DNY
     15.0          $ Increment in shear resultant Nxy:  DNXY
        0          $ Increment in axial moment resultant Mx:  DMX
        0          $ Increment in circumferential moment resultant My:  DMY
        0          $ Increment in pressure, p:  DP
        0          $ Starting multiplier for temperature distribution, TMULT
        0          $ Multiplier increment for temperature distribution, DTMULT
       20          $ Maximum number of load steps, NSTEPS
```

Simulate a test on the optimized panel under increasing load.

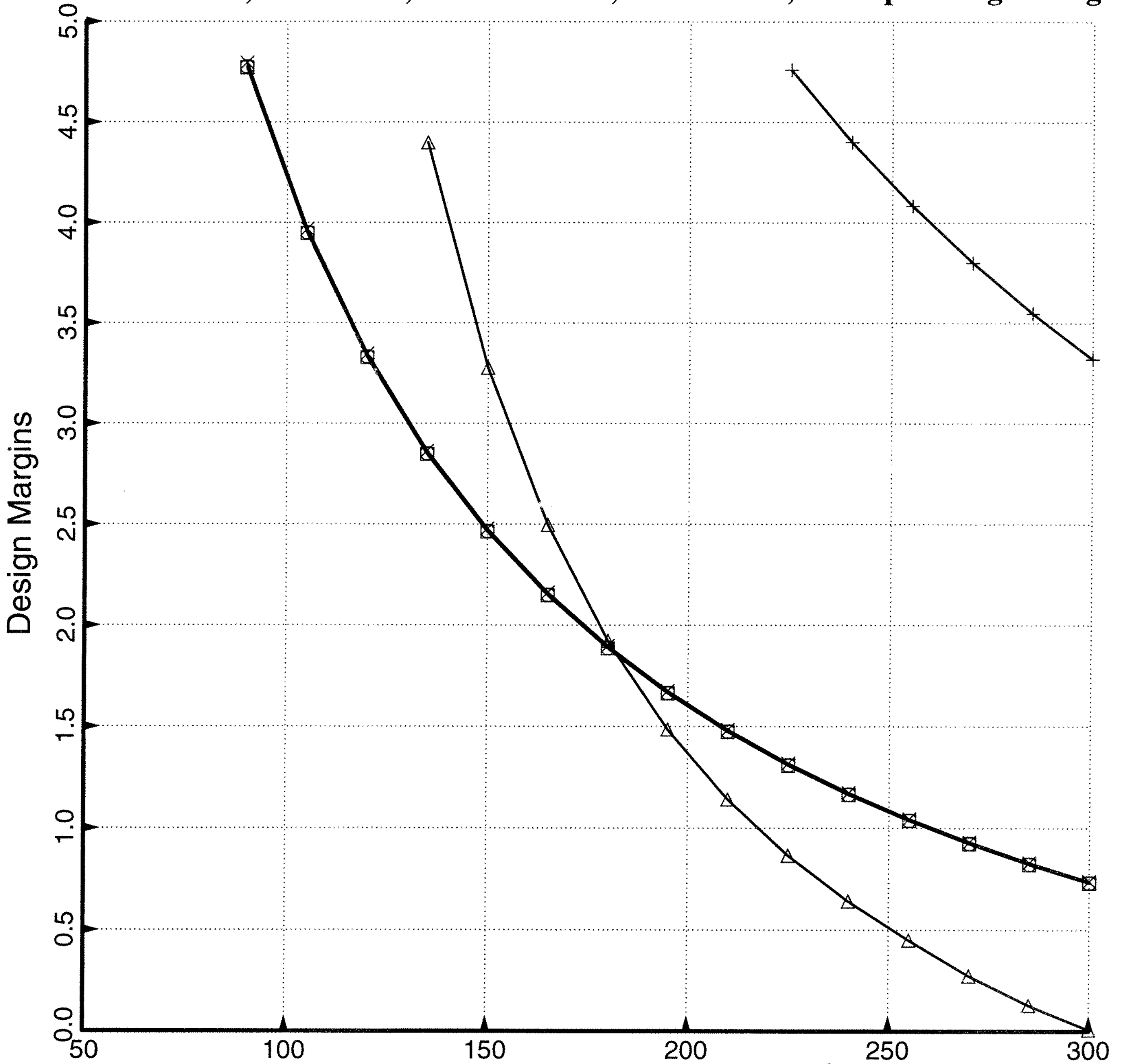
Table 2.10 flat.CPL = flat.shear.cpl31

```
n          $ Do you want a tutorial session and tutorial output?
   1       $ For which load set (1 - 5) do you want behavior/margins?
   1       $ Choose a sub-case (1 or 2) within this load set
   3       $ Indicate which load component to use in plots (1,2,...7)
y          $ Any behaviors to be plotted v. load steps (Y or N)?
   2       $ Choose a behavior to be plotted v. load steps
n          $ Any more behaviors to be plotted v. load steps (Y/N)?
y          $ Any extreme fiber strains to be plotted v. load steps?
   1       $ Choose (axial,hoop) or (+45deg,-45deg) strain plots (1 or 2)
   1       $ Choose a location (1, 2, ...) for strain plots
y          $ Any more locations for plotting v. load steps (Y/N)?
   6       $ Choose a location (1, 2, ...) for strain plots
n          $ Any more locations for plotting v. load steps (Y/N)?
y          $ Any design margins to be plotted (Y or N)?
   1       $ Choose a margin to be plotted v. iterations (1,2,3,..)
y          $ Any more margins to be plotted (Y or N) ?
   2       $ Choose a margin to be plotted v. iterations (1,2,3,..)
y          $ Any more margins to be plotted (Y or N) ?
   3       $ Choose a margin to be plotted v. iterations (1,2,3,..)
y          $ Any more margins to be plotted (Y or N) ?
   4       $ Choose a margin to be plotted v. iterations (1,2,3,..)
y          $ Any more margins to be plotted (Y or N) ?
   5       $ Choose a margin to be plotted v. iterations (1,2,3,..)
y          $ Any more margins to be plotted (Y or N) ?
   6       $ Choose a margin to be plotted v. iterations (1,2,3,..)
y          $ Any more margins to be plotted (Y or N) ?
   7       $ Choose a margin to be plotted v. iterations (1,2,3,..)
n          $ Any more margins to be plotted (Y or N) ?
   5       $ Give maximum value (positive) to be included in plot frame.
y          $ Any deformed panel module cross sections to be plotted?
   2       $ Choose a load step for which to plot the panel module
y          $ Any more load steps for which to plot panel module (Y/N)?
   5       $ Choose a load step for which to plot the panel module
y          $ Any more load steps for which to plot panel module (Y/N)?
   7       $ Choose a load step for which to plot the panel module
y          $ Any more load steps for which to plot panel module (Y/N)?
  10       $ Choose a load step for which to plot the panel module
y          $ Any more load steps for which to plot panel module (Y/N)?
  13       $ Choose a load step for which to plot the panel module
y          $ Any more load steps for which to plot panel module (Y/N)?
  17       $ Choose a load step for which to plot the panel module
y          $ Any more load steps for which to plot panel module (Y/N)?
  20       $ Choose a load step for which to plot the panel module
n          $ Any more load steps for which to plot panel module (Y/N)?
n          $ Do you want to plot layers in skin-stringer module (Y/N)?
y          $ Do you want a "3-D" plot of the buckled panel module (Y/N)?
```

Flat.3.ps (from flat.shear.cpl31)

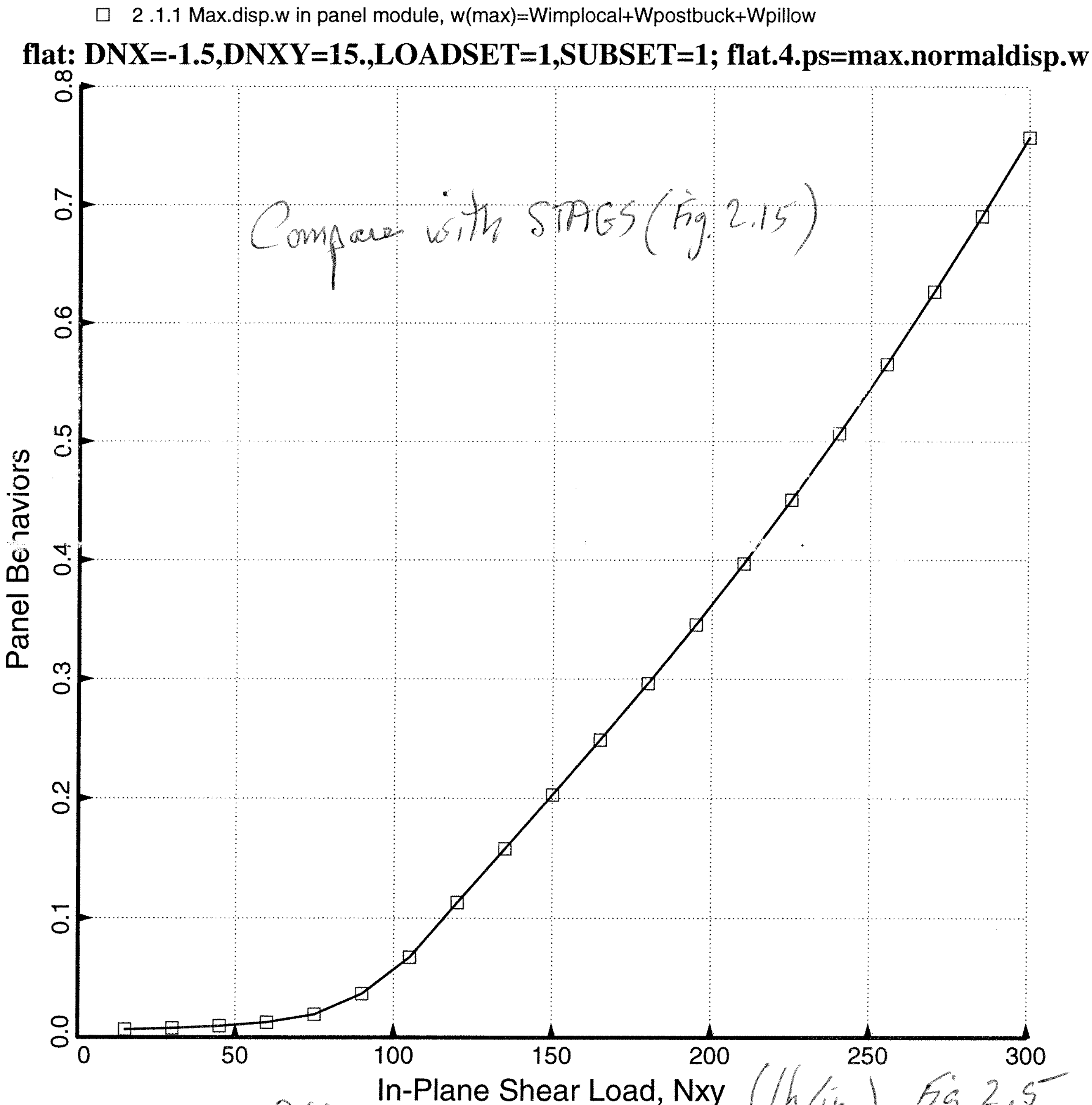
□ 1 .1.1 Local buckling: discrete model
○ 2 .1.1 Local buckling: Koiter theory.
△ 3 .1.1 eff.stress:matl=1; MID.
+ 4 .1.1 eff.stress:matl=1,allnode;-MID.
× 5 .1.1 buck(DONL)simp-support general buck; MIDLENGTH

flat: DNX=-1.5,DNXY=15., LOADSET=1, SUBSET=1; flat.3.ps=design margins



267 In-Plane Shear Load, Nxy (lb/in) Fig. 2.4

Flat.4.ps (from flat.shear.cpl31)



(lb/in) Fig. 2.5

268

flat.5.ps (from flat, shear, cp131)

□ 2 .1.1 Panel module deformed by loads in step no. 2
○ 5 .1.1 Panel module deformed by loads in step no. 5
△ 7 .1.1 Panel module deformed by loads in step no. 7
+ 10.1.1 Panel module deformed by loads in step no. 10
× 13.1.1 Panel module deformed by loads in step no. 13
◇ 17.1.1 Panel module deformed by loads in step no. 17
▽ 20.1.1 Panel module deformed by loads in step no. 20

flat: DNX=-1.5,DNXY=15., LOADSET=1, SUBSET=1; flat.5.ps=w vs. width coord. y

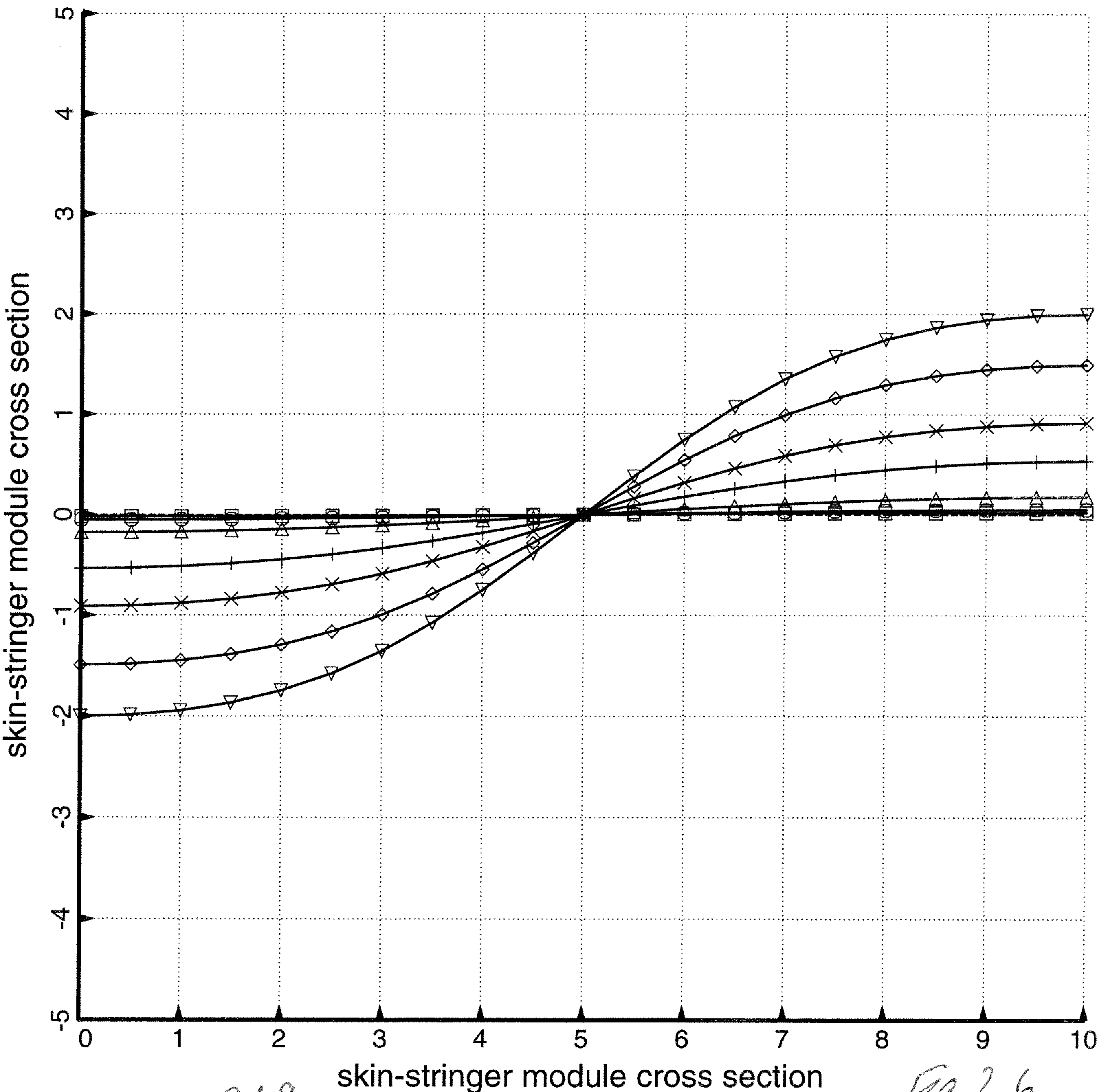
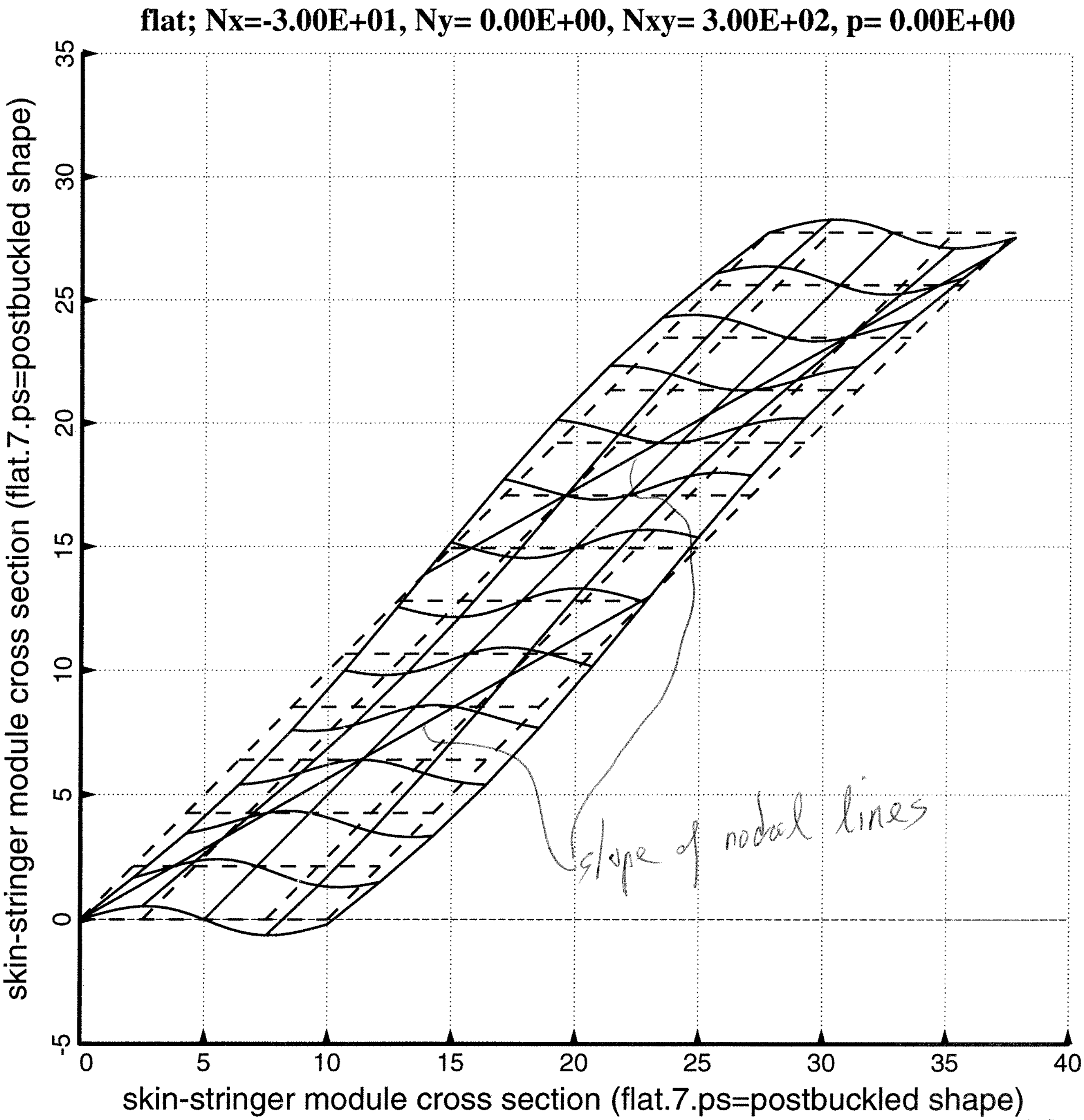


Fig. 2.6

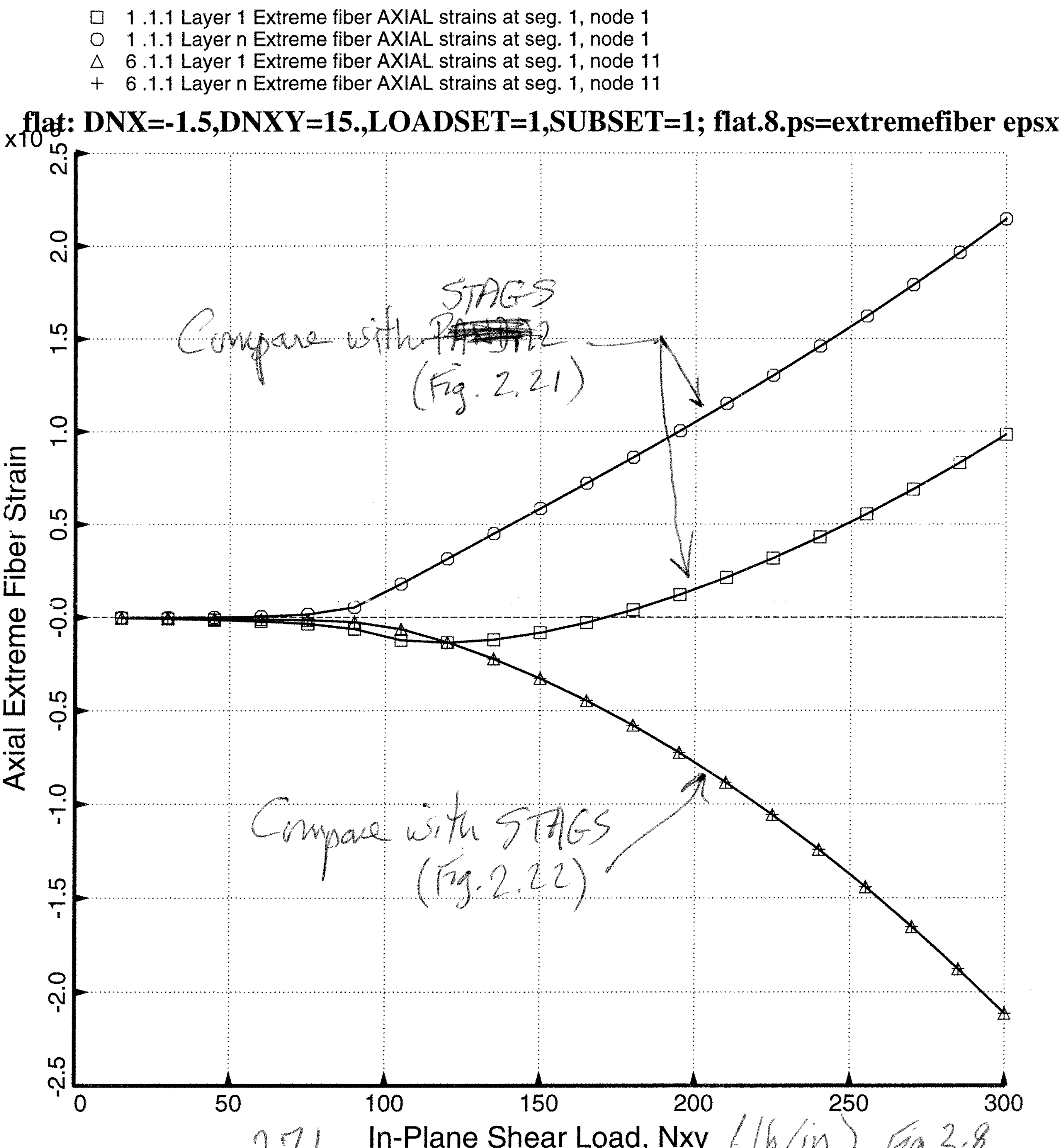
flat.7.ps (from flat.shear.cpl31)



270

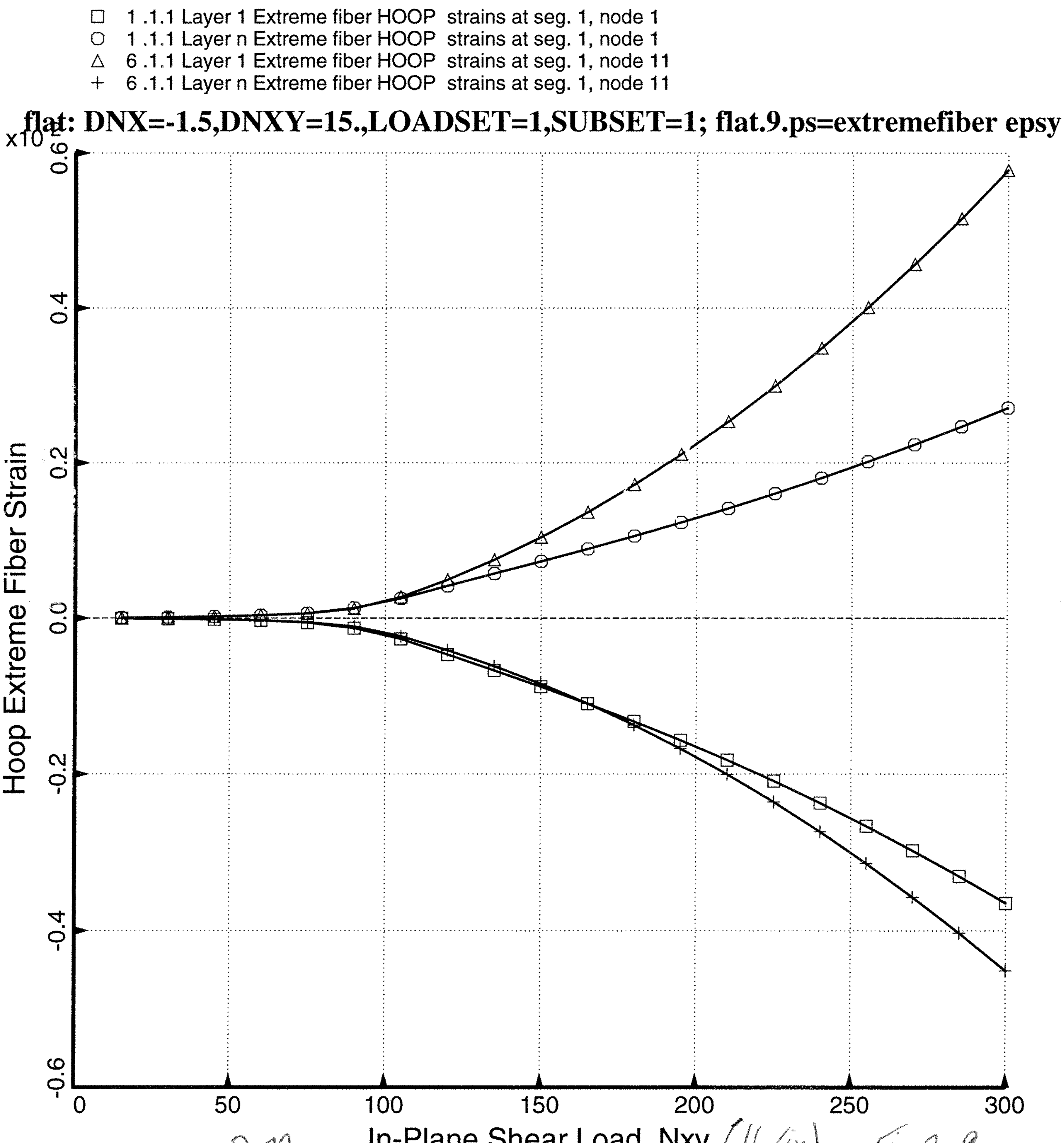
Fig. 2.7

flat.8.ps (from flat.shear.cpl31)



271 (lb/in) Fig. 2.8

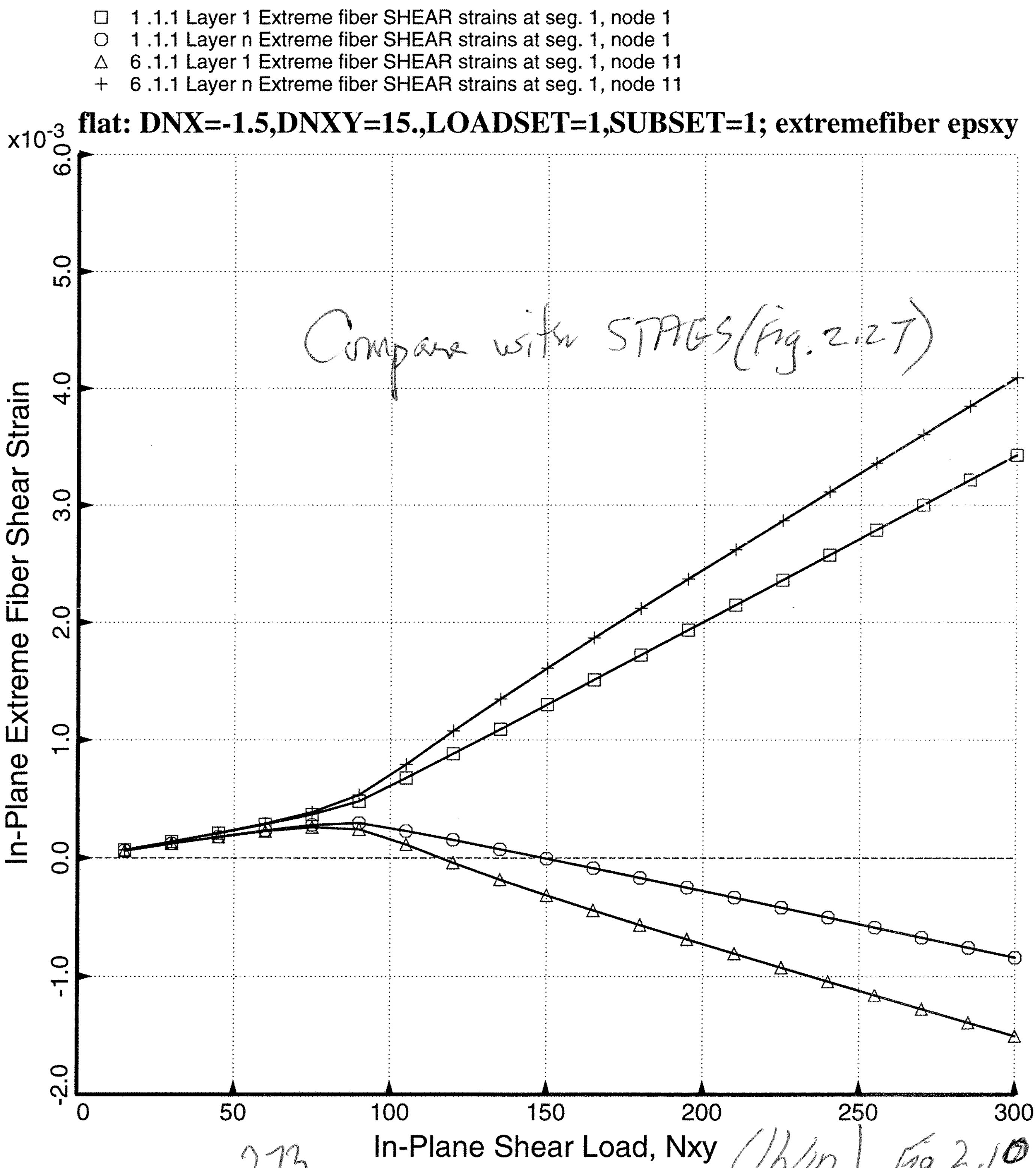
flat.9.ps (from flat.shear.cpl31)



272

Fig. 2.9

Flat.10.ps (from flat.shear.cpl31)



273

Fig. 2.10

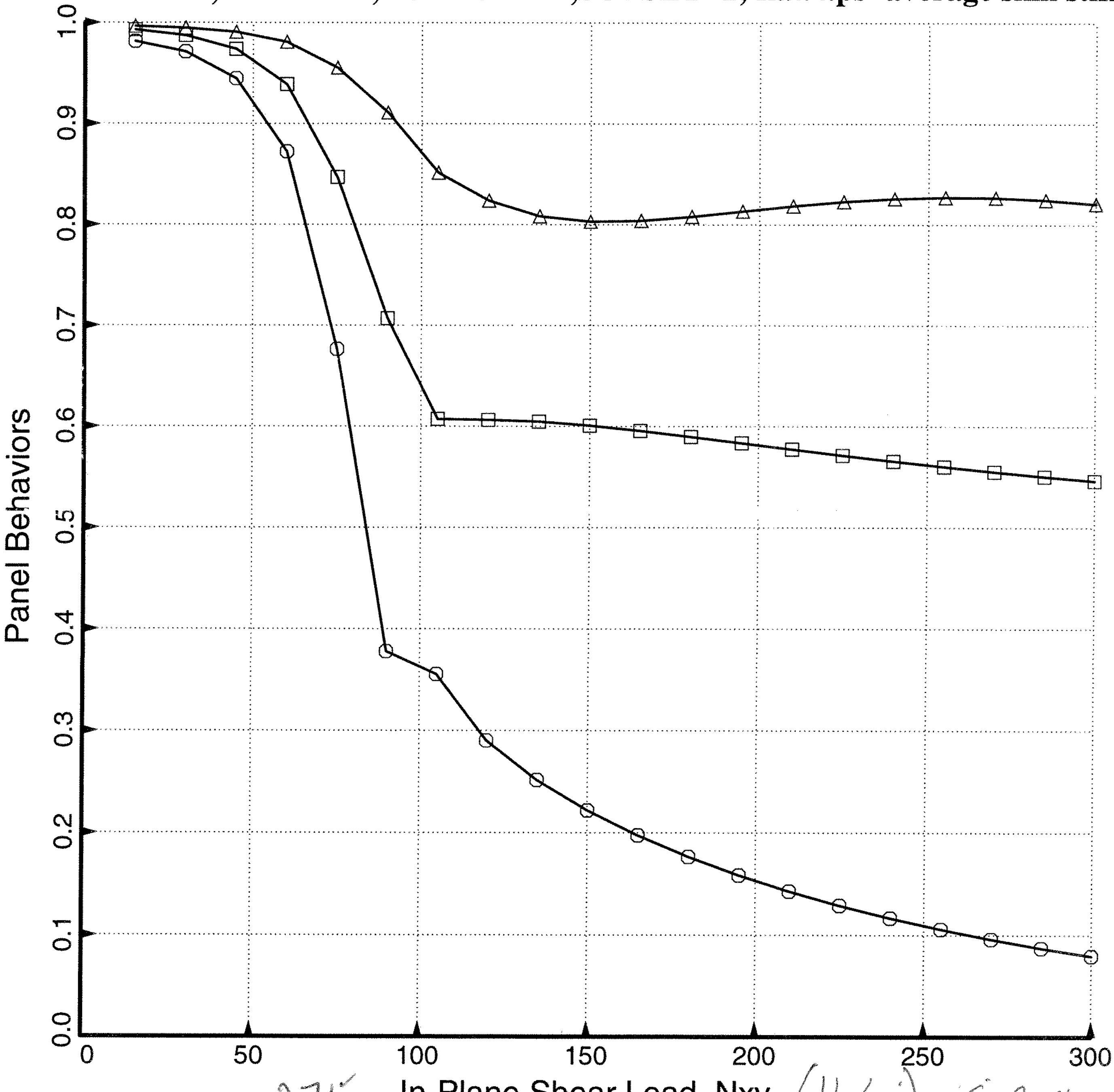
Table 2.11 Flat.CPL (flat.shear.cpl32)

```
n         $ Do you want a tutorial session and tutorial output?
   1      $ For which load set (1 - 5) do you want behavior/margins?
   1      $ Choose a sub-case (1 or 2) within this load set
   3      $ Indicate which load component to use in plots (1,2,...7)
y         $ Any behaviors to be plotted v. load steps (Y or N)?
   7      $ Choose a behavior to be plotted v. load steps
y         $ Any more behaviors to be plotted v. load steps (Y/N)?
   8      $ Choose a behavior to be plotted v. load steps
y         $ Any more behaviors to be plotted v. load steps (Y/N)?
   9      $ Choose a behavior to be plotted v. load steps
n         $ Any more behaviors to be plotted v. load steps (Y/N)?
n         $ Any extreme fiber strains to be plotted v. load steps?
n         $ Any design margins to be plotted (Y or N)?
n         $ Any deformed panel module cross sections to be plotted?
n         $ Do you want to plot layers in skin-stringer module (Y/N)?
n         $ Do you want a "3-D" plot of the buckled panel module (Y/N)?
```

Flat.4.ps (from flat.shear.cpl32)

□ 7 .1.1 Normalized average axial skin stiff: Ctan11/C0(1,1)
○ 8 .1.1 Normalized average hoop skin stiff: Ctan22/C0(2,2)
△ 9 .1.1 Normalized average shear skin stiff: Ctan33/C0(3,3)

flat: DNX=-1.5,DNXY=15.,LOADSET=1,SUBSET=1; flat.4.ps=average skin stiffness



275 (lb/in) Fig. 2.11

Table 2.12 flat.OPT (fixed design)

```
    n          $ Do you want a tutorial session and tutorial output?
  -30.000      $ Resultant (e.g. lb/in) normal to the plane of screen, Nx( 1)
      0        $ Resultant (e.g. lb/in) in the plane of the screen,    Ny( 1)
   300.00      $ In-plane shear in load set A,                  Nxy( 1)
    n          $ Does the axial load vary in the L2 direction?
 0.000000      $ Applied axial moment resultant (e.g. in-lb/in), Mx( 1)
 0.000000      $ Applied hoop moment resultant (e.g. in-lb/in), My( 1)
    Y          $ Want to include effect of transverse shear deformation?
      0        $ IQUICK = quick analysis indicator (0 or 1)
    Y          $ Do you want to vary M for minimum local buckling load?
    N          $ Do you want to choose a starting M for local buckling?
    Y          $ Do you want to perform a "low-axial-wavenumber" search?
0.2000000      $ Factor of safety for general instability, FSGEN( 1)
0.2000000      $ Minimum load factor for local buckling (Type H for HELP), FSLOC( 1)
 1.000000      $ Minimum load factor for stiffener buckling (Type H), FSBSTR( 1)
 1.000000      $ Factor of safety for stress, FSSTR( 1)
    Y          $ Do you want "flat skin" discretized module for local buckling?
    N          $ Do you want wide-column buckling to constrain the design?
 0.000000      $ Resultant (e.g. lb/in) normal to the plane of screen, Nx0( 1)
 0.000000      $ Resultant (e.g. lb/in) in the plane of the screen,    Ny0( 1)
      0        $ Axial load applied along the (0=neutral plane), (1=panel skin)
 0.000000      $ Uniform applied pressure [positive upward. See H(elp)], p( 1)
 0.000000      $ Out-of-roundness, Wimpg1=(Max.diameter-Min.diam)/4, Wimpg1( 1)
 0.010000      $ Initial buckling modal general imperfection amplitude, Wimpg2( 1)
 0.010000      $ Initial local imperfection amplitude (must be positive), Wloc( 1)
    Y          $ Do you want PANDA2 to change imperfection amplitudes (see H(elp))?( 1)
     50        $ Axial halfwavelength of typical general buckling mode, AXLWAV( 1)
    Y          $ Do you want PANDA2 to find the general imperfection shape?( 1)
 1.000000      $ Maximum allowable average axial strain (type H for HELP)( 1)
    N          $ Is there any thermal "loading" in this load set (Y/N)?
    Y          $ Do you want a "complete" analysis (type H for "Help")?
    N          $ Want to provide another load set ?
    N          $ Do you want to impose minimum TOTAL thickness of any segment?
    N          $ Do you want to impose maximum TOTAL thickness of any segment?
    N          $ Use reduced effective stiffness in panel skin (H(elp), Y or N)?
      2        $ NPRINT= output index (-1=min. 0=good, 1=ok, 2=more, 3=too much)
      0        $ Index for type of shell theory (0 or 1 or 2), ISAND
    Y          $ Does the postbuckling axial wavelength of local buckles change?
    Y          $ Want to suppress general buckling mode with many axial waves?
    N          $ Do you want to double-check PANDA-type eigenvalues [type (H)elp]?
      0        $ Choose (0=transverse inextensional; 1=transverse extensional)
      1        $ Choose ICONSV = -1 or 0 or 1 or H(elp), ICONSV
      2        $ Choose type of analysis (ITYPE = 1 or 2 or 3 or 4 or 5)
    Y          $ Do you want to prevent secondary buckling (mode jumping)?
    N          $ Do you want to use the "alternative" buckling solution?
      5        $ How many design iterations permitted in this run (5 to 25)?
 1.000000      $ MAXMAR. Plot only those margins less than MAXMAR (Type H)
    N          $ Do you want to reset total iterations to zero (Type H)?
      1        $ Index for objective (1=min. weight, 2=min. distortion)
 1.000000      $ FMARG (Skip load case with min. margin greater than FMARG)
```

flat.shear.itype2.opt

input for MAINSETUP

Table 2.13 flat.STG = flat.shear.stg

```
    n         $ Do you want a tutorial session and tutorial output?
      1       $ Choose type of STAGS analysis (1,3,4,5,6),INDIC
      0       $ Restart from ISTARTth load step (0=1st nonlinear soln), ISTART
0.3000000     $ Local buckling load factor from PANDA2, EIGLOC
    y         $ Are the dimensions in this case in inches?
      0       $ Nonlinear (0) or linear (1) kinematic relations?, ILIN
      0       $ Type 1 for closed (360-deg) cyl. shell, 0 otherwise, ITOTAL
     50       $ X-direction length of the STAGS model of the panel: XSTAGS
     10       $ Panel length in the plane of the screen, L2
    y         $ Is the nodal point spacing uniform along the stringer axis?
     51       $ Number of nodes in the X-direction: NODEX
-30.00000     $ Resultant (e.g. lb/in) normal to the plane of screen, Nx
      0       $ Resultant (e.g. lb/in) in the plane of the screen,    Ny
 300.0000     $ In-plane shear in load set A,                       Nxy
      0       $ Normal pressure in STAGS model in Load Set A, p
      0       $ Resultant (e.g. lb/in) normal to the plane of screen, Nx0
      0       $ Resultant (e.g. lb/in) in the plane of the screen,    Ny0
      0       $ Normal pressure in STAGS model in Load Set B, p0
      1       $ Starting load factor for Load System A, STLD(1)
      0       $ Load factor increment for Load System A, STEP(1)
      1       $ Maximum load factor for Load System A, FACM(1)
      0       $ Starting load factor for Load System B, STLD(2)
      0       $ Load factor increment for Load System B, STEP(2)
      0       $ Maximum load factor for Load System B, FACM(2)
      1       $ How many eigenvalues do you want? NEIGS
    480       $ Choose element type (410 or 411 or 480) for panel skin
    n         $ Have you obtained buckling modes from STAGS for this case?
      0       $ Number of stringers in STAGS model of the flat panel
      0       $ Number of rings in the STAGS model of the panel
    n         $ Are there rings at the ends of the panel?
     10       $ Number of finite elements between adjacent stringers
     25       $ Number of finite elements between adjacent rings
      3       $ Stringer model: 1 or 2 or 3 or 4 or 5(Type H(elp))
      3       $ Ring model: 1 or 2 or 3 or 4 or 5 (Type H(elp))
      0       $ Reference surface of cyl: 1=outer, 0=middle, -1=inner
    n         $ Do you want to use fasteners (they are like rigid links)?
    y         $ Are the stringers to be "smeared out"?
    y         $ Are the rings to be "smeared out"?
      5       $ Number of nodes over height of stiffener webs, NODWEB
      5       $ Number of nodes over width of stringer flange, NDFLGS
      5       $ Number of nodes over width of ring flange, NDFLGR
    n         $ Do you want stringer(s) with a high nodal point density?
    n         $ Do you want ring(s) with a high nodal point density?
    n         $ Is there plasticity in this STAGS model?
    n         $ Do you want to use the "least-squares" model for torque?
    n         $ Is stiffener sidesway permitted at the panel edges?
    n         $ Do you want symmetry conditions along the straight edges?
      0       $ Edges normal to screen (0) in-plane deformable; (1) rigid
```

input for STAGSUNIT

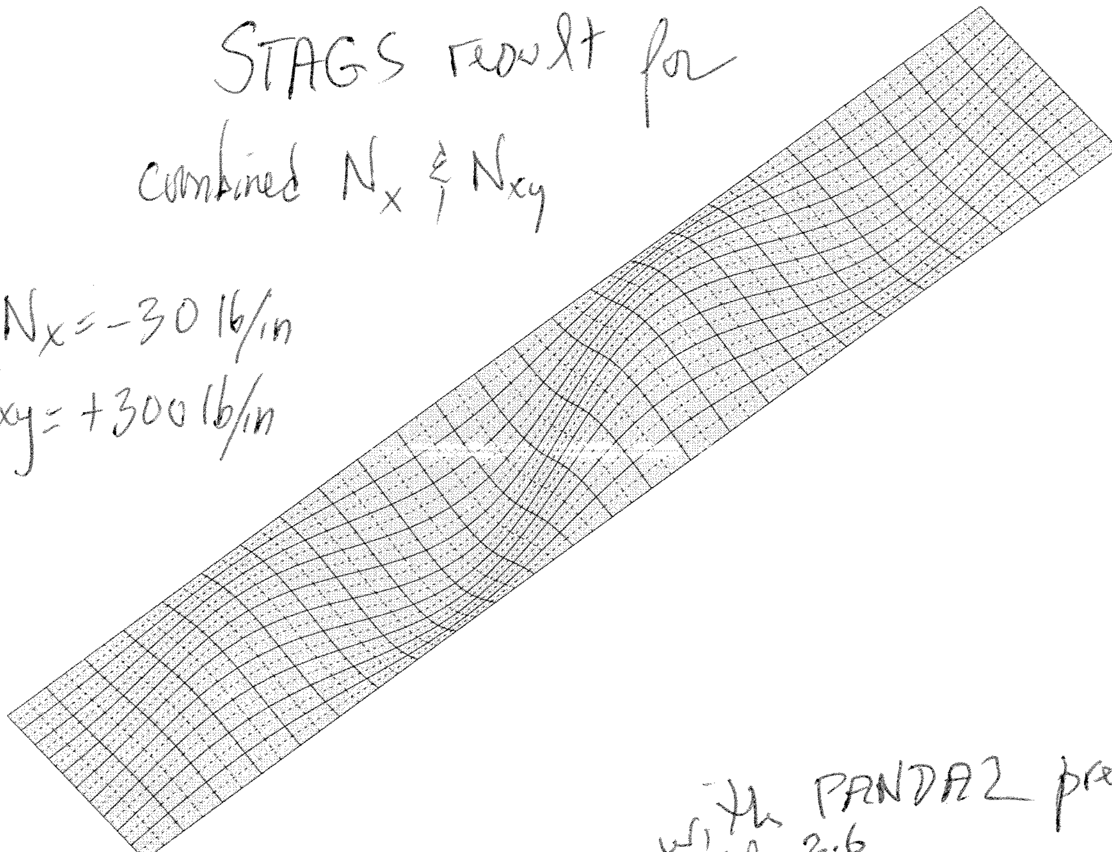
Output from STAGS in Figs. 2.12 – 2.27

flat.linbuck.deformed.shearload.pdf

STAGS result for combined N_x & N_{xy}

$N_x = -30$ lb/in

$N_{xy} = +300$ lb/in



compare with the PANDA2 prediction listed in Table 2.6

solution scale = 0.2866E+01
mode 1, $\boxed{\text{pcr = 0.34059E+00}}$
step 0 eigenvector deformed geometry
linear buckling of perfect shell

Θ x -35.84
Θ y -13.14
Θ z 35.63

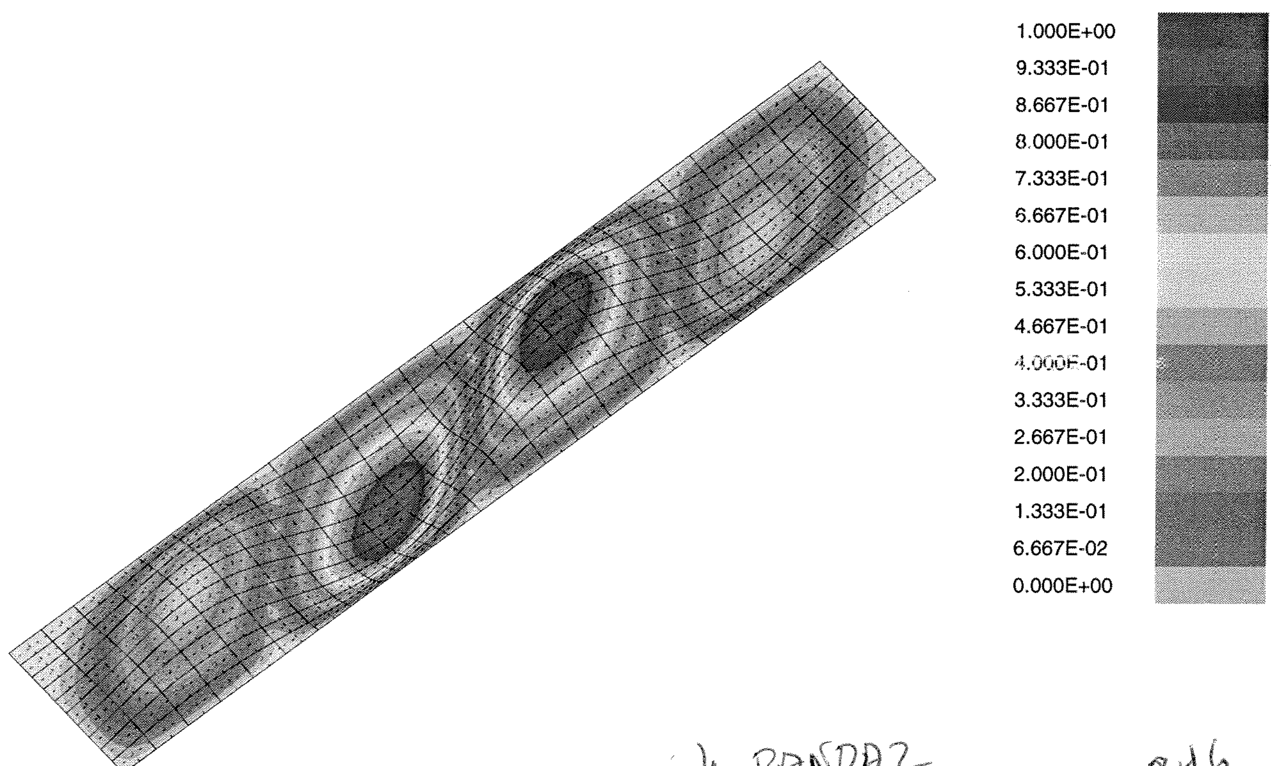
y z x

7.541E+00

Fig. 2.12

flat.linbuck.wfringe.shearload.pdf

STAGS result



compare with PANDA2 prediction in Table 2.6 : $\lambda = 0.346$

solution scale = 0.2866E+01

mode 1, pcr = 0.34059E+00

step 0 eigenvector veclngthcontours

linear buckling of perfect shell,fringe plot of modal displacement

Minimum value = 0.00000E+00, Maximum value = 1.00000E+00

Θ x -35.84
Θ y -13.14
Θ z 35.63

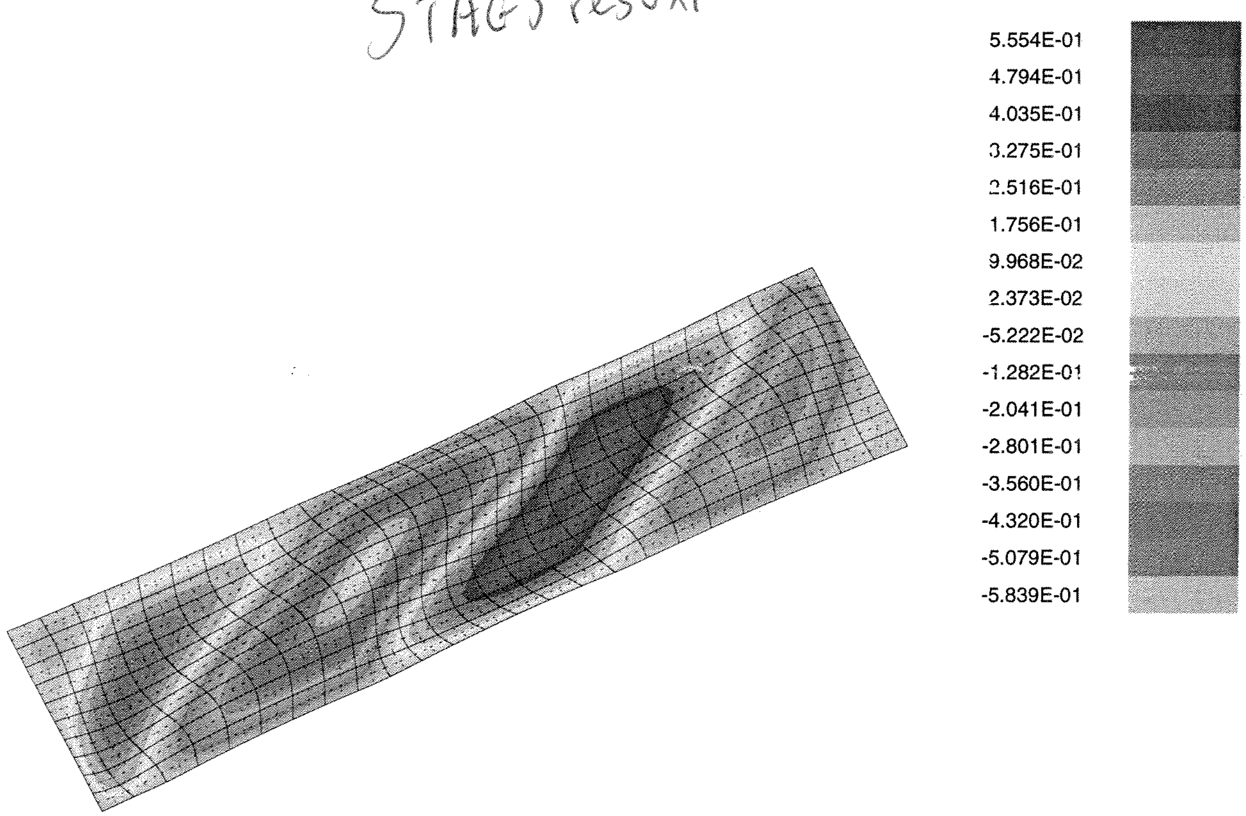
y z x

9.050E+00

Fig. 2.13

Flat.postbuck.wfringe.shearload.pdf

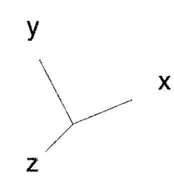
STAGS result



solution scale = 0.4438E+01
PA= 1.00000E+00 PB= 0.00000E+00 PX= 0.00000E+00
step 34 displacement w contours
nonlinear w
Minimum value = -5.83871E-01, Maximum value = 5.55384E-01

Θ x 24.00
Θ y -22.00
Θ z 30.00

8.957E+00



280

Fig. 2.14

flatshear.w.ps

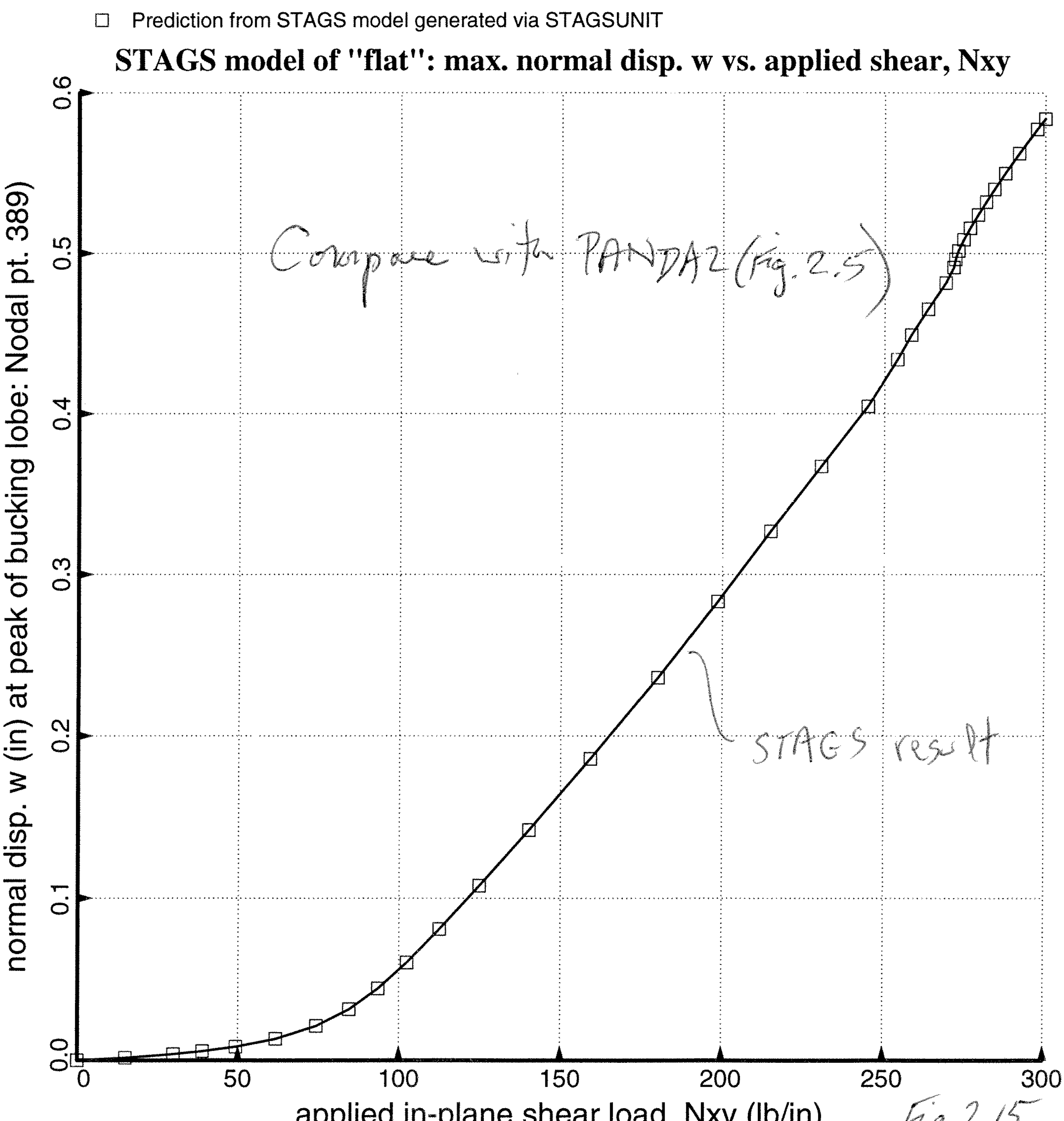


Fig. 2.15

281

flatshear.w.stagspanda2.ps

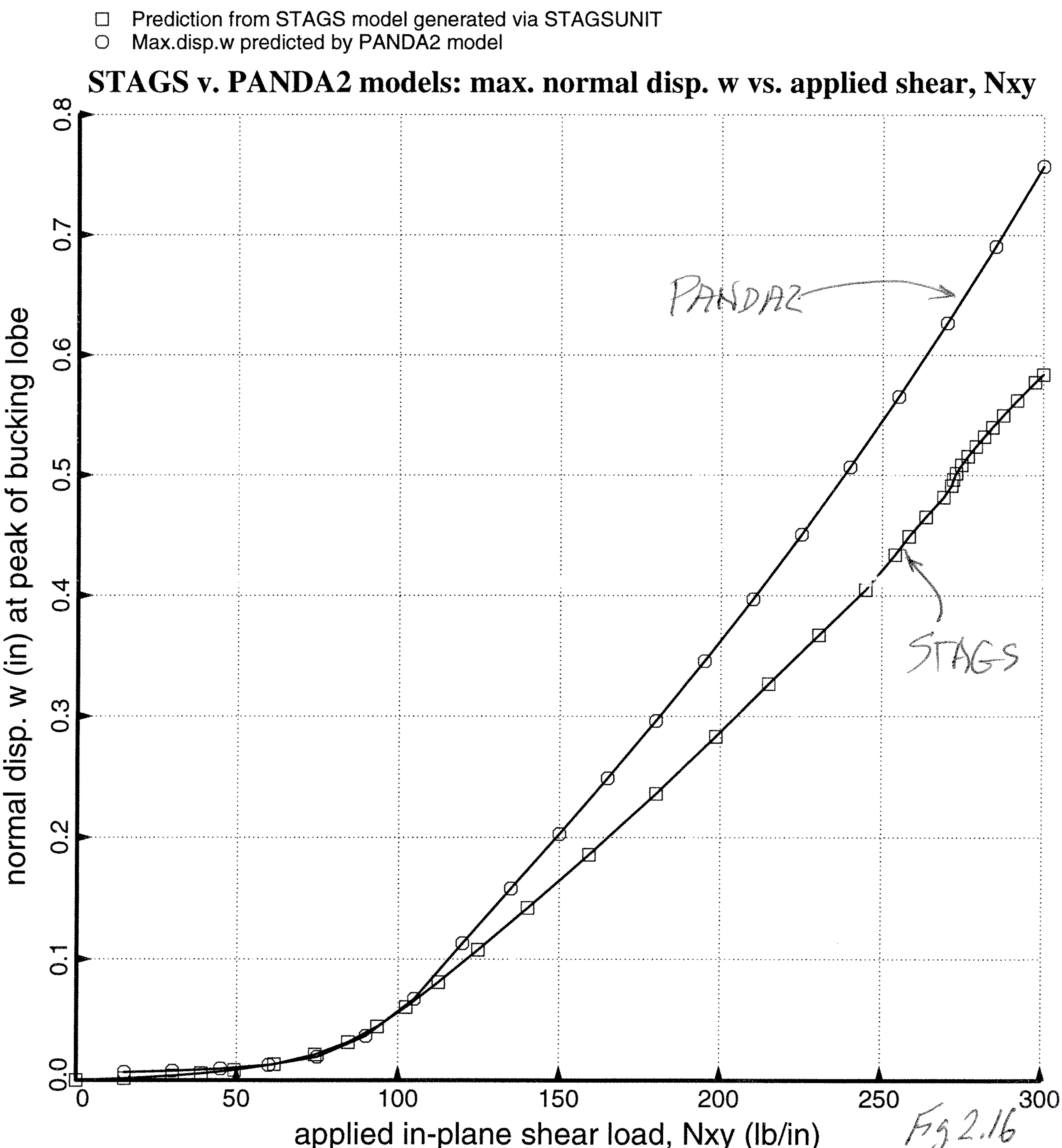
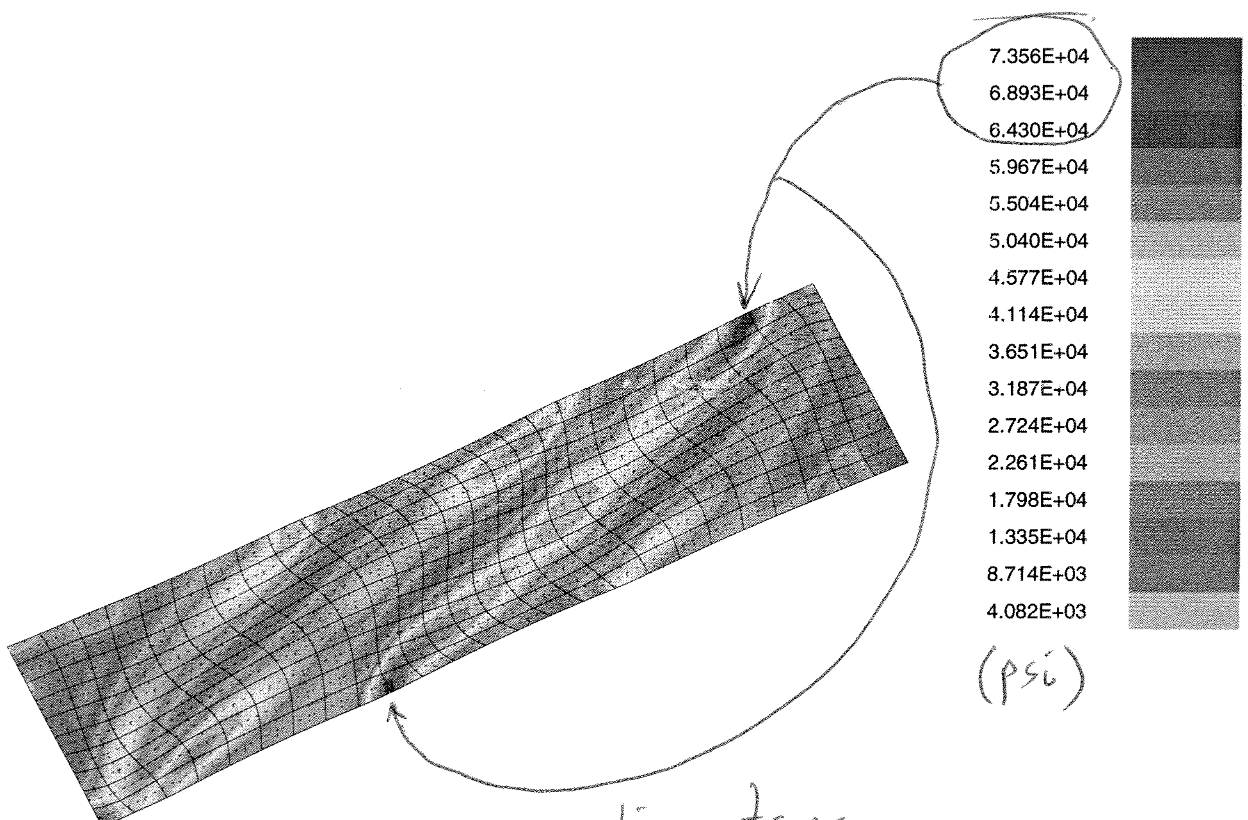


Fig 2.16

282

flat.postbuck.seff.innerfiber.shearload.pdf



"effective stress

solution scale = 0.4438E+01
PA= 1.00000E+00 PB= 0.00000E+00 PX= 0.00000E+00
step 34 fabrication system seff layer 1, inner fiber
nonlinear effective stress - ~~inner~~ fiber ok as is
Minimum value = 4.08218E+03, Maximum value = 7.35642E+04

Θ x 24.00
Θ y -22.00
Θ z 30.00

8.957E+00

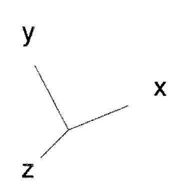
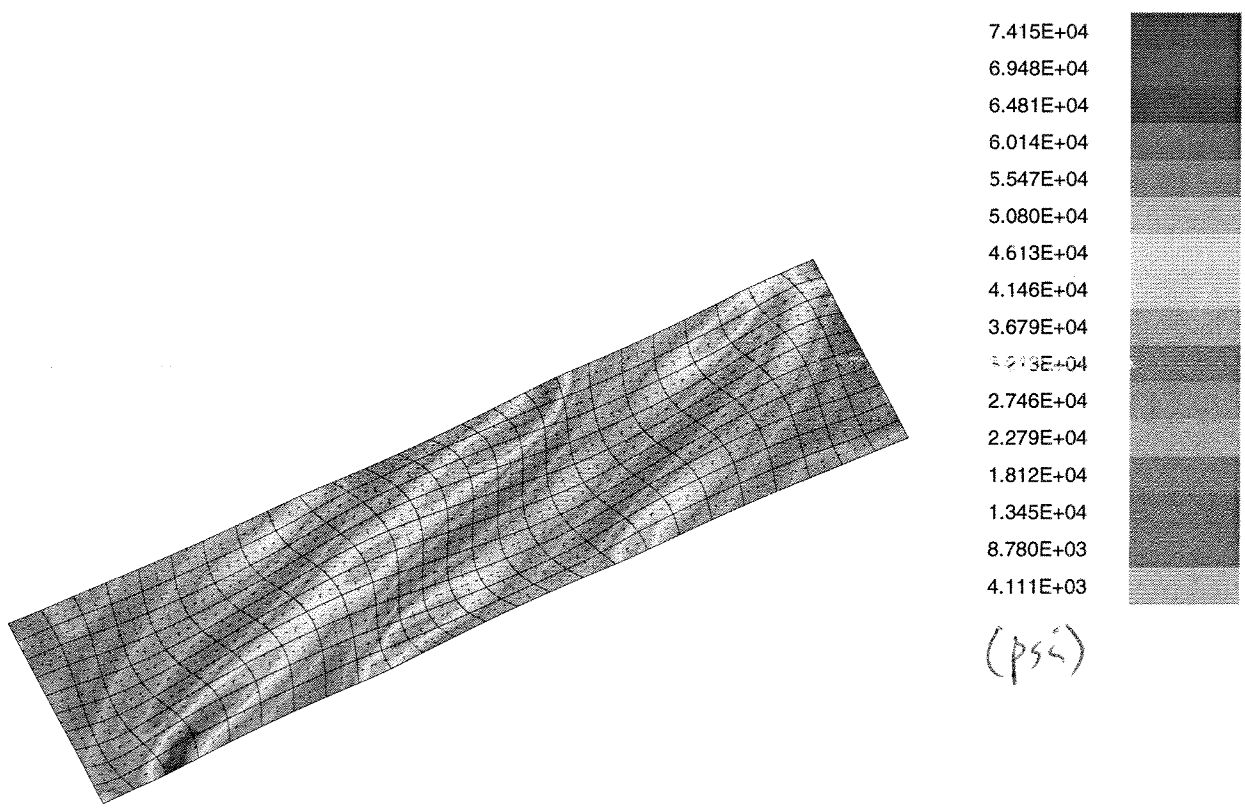


Fig. 2.17



solution scale = 0.4438E+01

PA= 1.00000E+00 PB= 0.00000E+00 PX= 0.00000E+00

step 34 fabrication system ,seff, layer 1, outer fiber

nonlinear effective stress - ~~inner~~ outer fiber

Minimum value = 4.11134E+03, Maximum value = 7.41460E+04

Θ x 24.00
Θ y -22.00
Θ z 30.00

8.957E+00

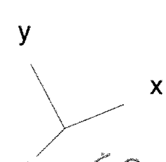
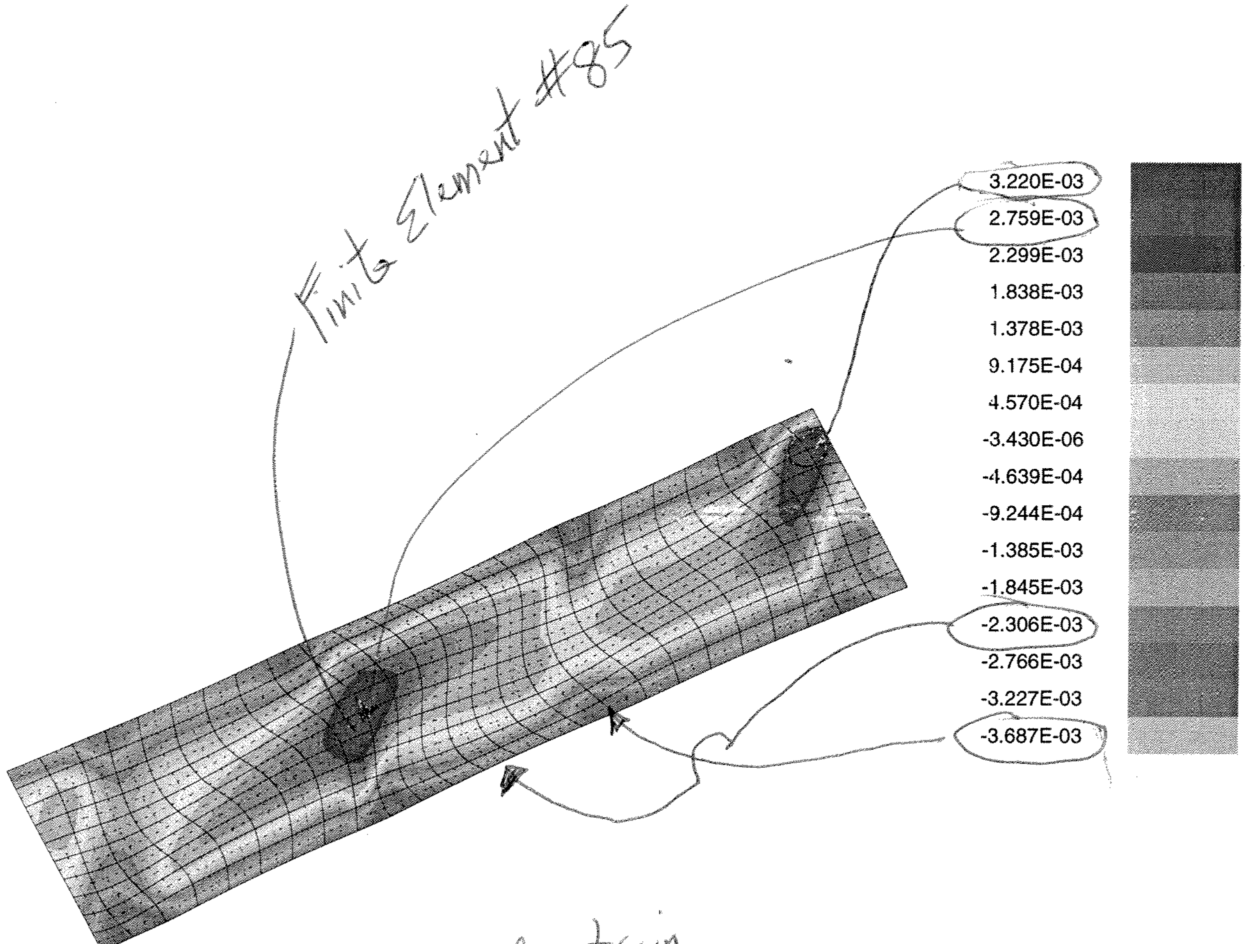


Fig 2.18

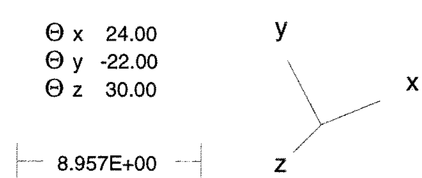
flat.postbuck.epsx.innerFiber.shearload.pdf



axial strain

solution scale = 0.4438E+01
PA= 1.00000E+00 PB= 0.00000E+00 PX= 0.00000E+00
step 34 strains , ex, layer 1, inner fiber
nonlinear axial strain - inner fiber
Minimum value = -3.68712E-03, Maximum value = 3.21980E-03

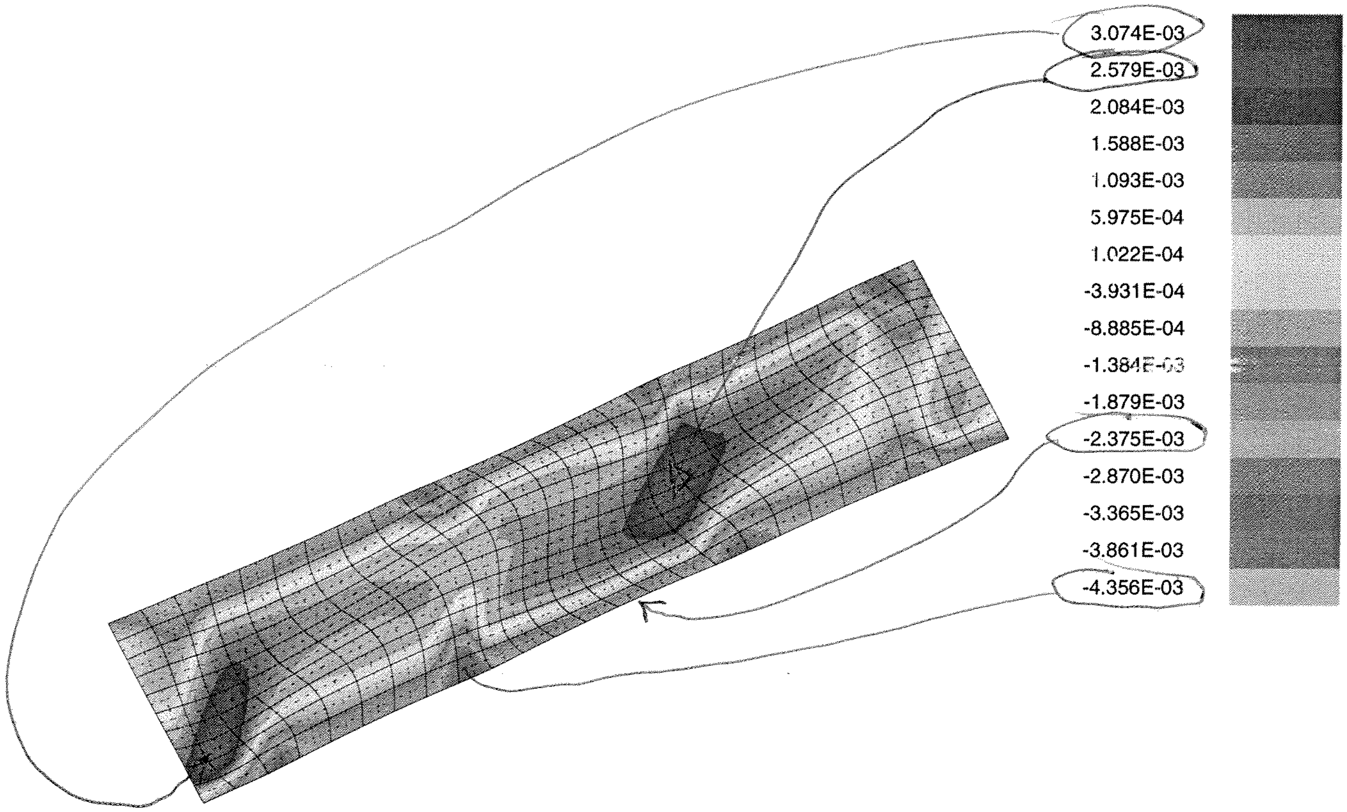
Θ x 24.00
Θ y -22.00
Θ z 30.00



285

Fig. 2.19

flat.postbuck.epsx.outerfiber.shearload.pdf



solution scale = 0.4438E+01
PA= 1.00000E+00 PB= 0.00000E+00 PX= 0.00000E+00
step 34 strains , ex, layer 1, outer fiber
nonlinear axial strain - outer fiber
Minimum value = -4.35588E-03, Maximum value = 3.07424E-03

Θ x 24.00
Θ y -22.00
Θ z 30.00

8.957E+00

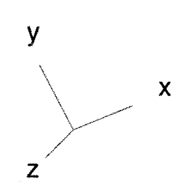


Fig. 2.20

flatshear.epsx.atbuckle.ps

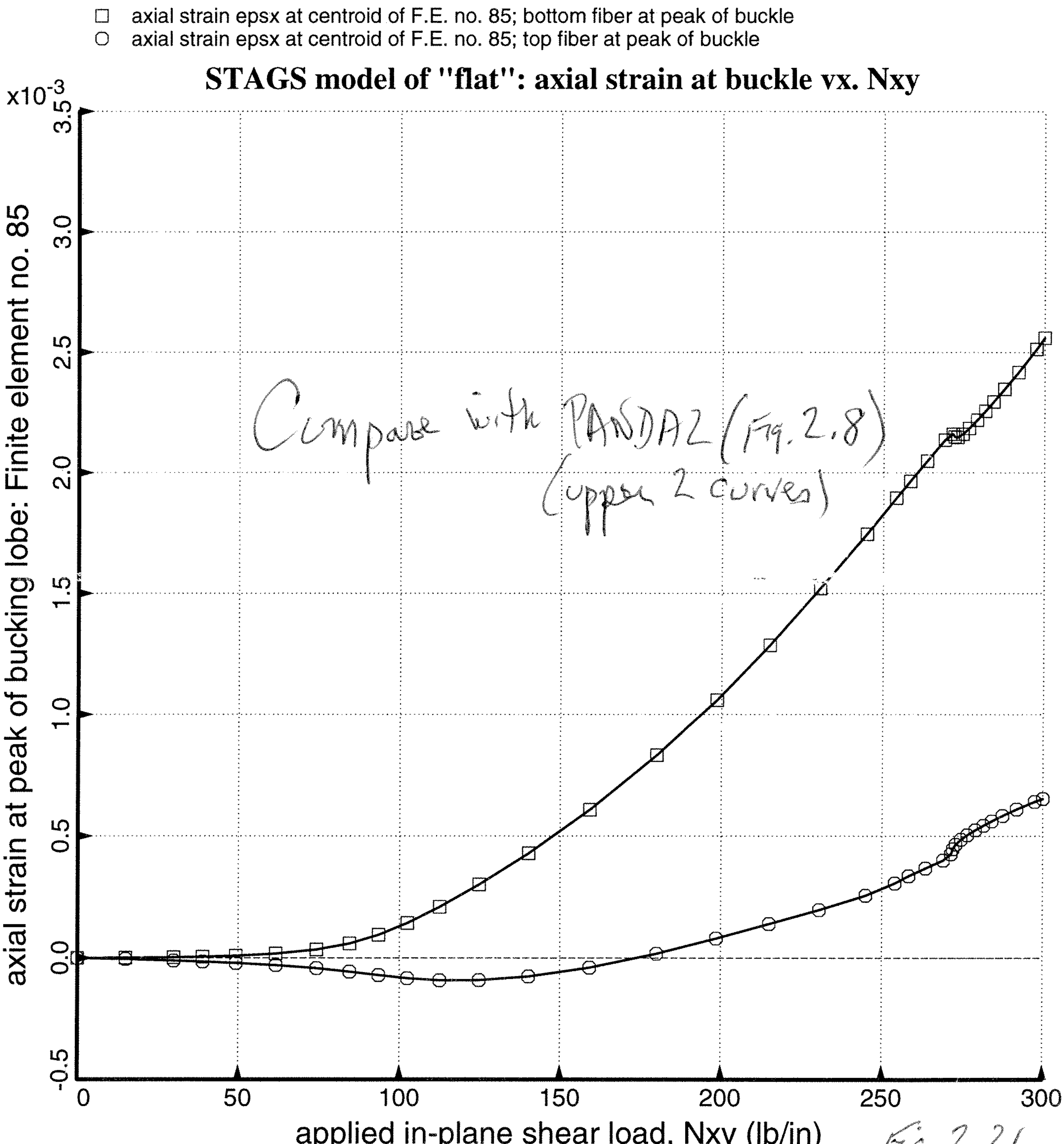


Fig. 2.21

□ axial strain epsx at integration pt. 1 of F.E. no. 121; bottom fiber near long edge
○ axial strain epsx at integration pt. 2 of F.E. no. 121; bottom fiber near long edge
△ axial strain epsx at integration pt. 3 of F.E. no. 121; bottom fiber near long edge
\+ axial strain epsx at integration pt. 4 of F.E. no. 121; bottom fiber near long edge
× axial strain epsx at integration pt. 5 of F.E. no. 121; bottom fiber near long edge
◇ axial strain epsx at integration pt. 6 of F.E. no. 121; bottom fiber near long edge
▽ axial strain epsx at integration pt. 7 of F.E. no. 121; bottom fiber near long edge
⊠ axial strain epsx at integration pt. 8 of F.E. no. 121; bottom fiber near long edge
⋇ axial strain epsx at integration pt. 9 of F.E. no. 121; bottom fiber near long edge
⊕ axial strain epsx at integration pt. 1 of F.E. no. 121; top fiber near long edge
⊕ axial strain epsx at integration pt. 2 of F.E. no. 121; top fiber near long edge
⧖ axial strain epsx at integration pt. 3 of F.E. no. 121; top fiber near long edge
⊞ axial strain epsx at integration pt. 4 of F.E. no. 121; top fiber near long edge
⊠ axial strain epsx at integration pt. 5 of F.E. no. 121; top fiber near long edge
◬ axial strain epsx at integration pt. 6 of F.E. no. 121; top fiber near long edge
● axial strain epsx at integration pt. 7 of F.E. no. 121; top fiber near long edge
○ axial strain epsx at integration pt. 8 of F.E. no. 121; top fiber near long edge
□ axial strain epsx at integration pt. 9 of F.E. no. 121; top fiber near long edge

nearest the edge

nearest the edge

STAGS model of "flat": axial strain near long edge vx. Nxy

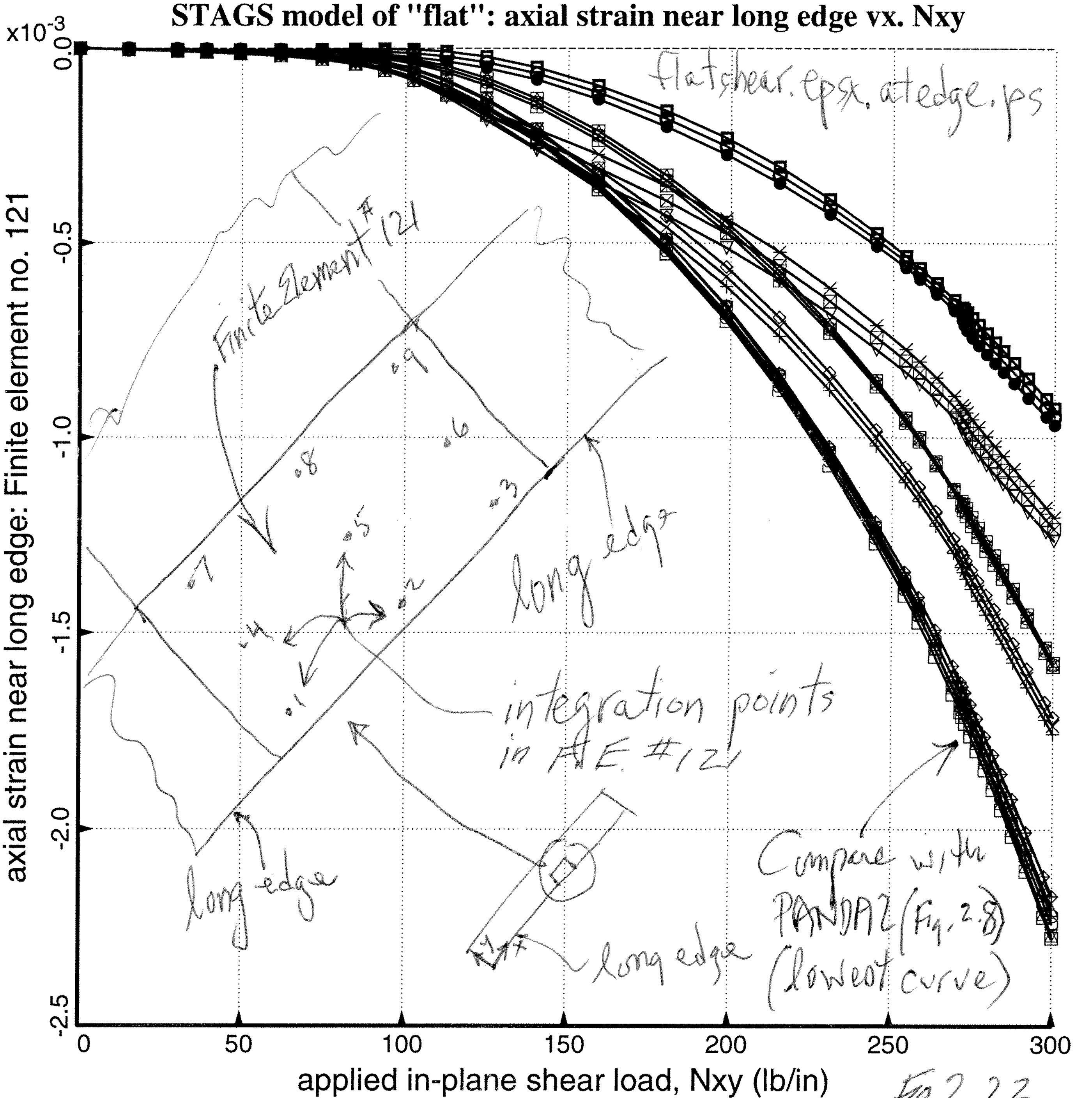
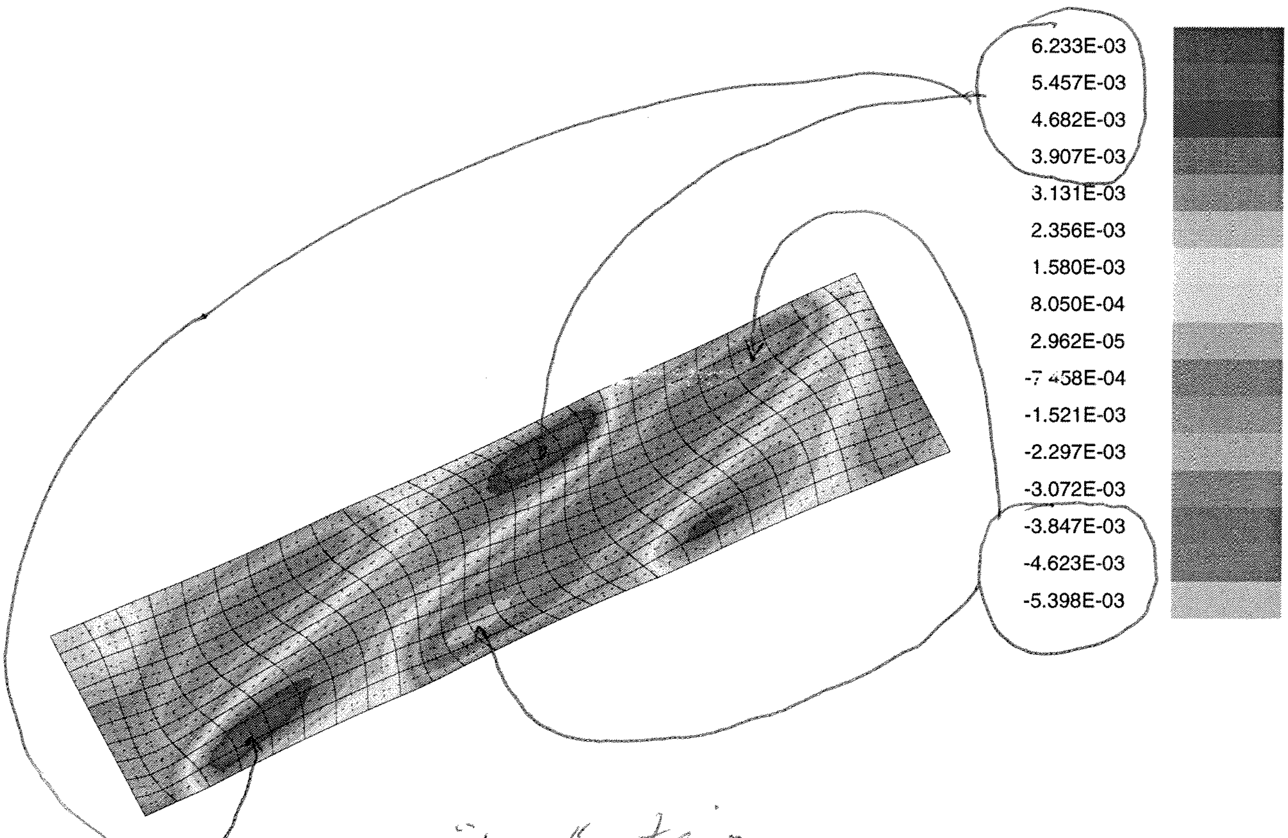


Fig. 2.22

flat. postbuck. epsy. innerfiber. shearload. pdf



"hoop" strain

solution scale = 0.4438E+01
PA= 1.00000E+00 PB= 0.00000E+00 PX= 0.00000E+00
step 34 strains , ey, layer 1, inner fiber
nonlinear hoop strain - inner fiber
Minimum value = -5.39816E-03, Maximum value = 6.23280E-03

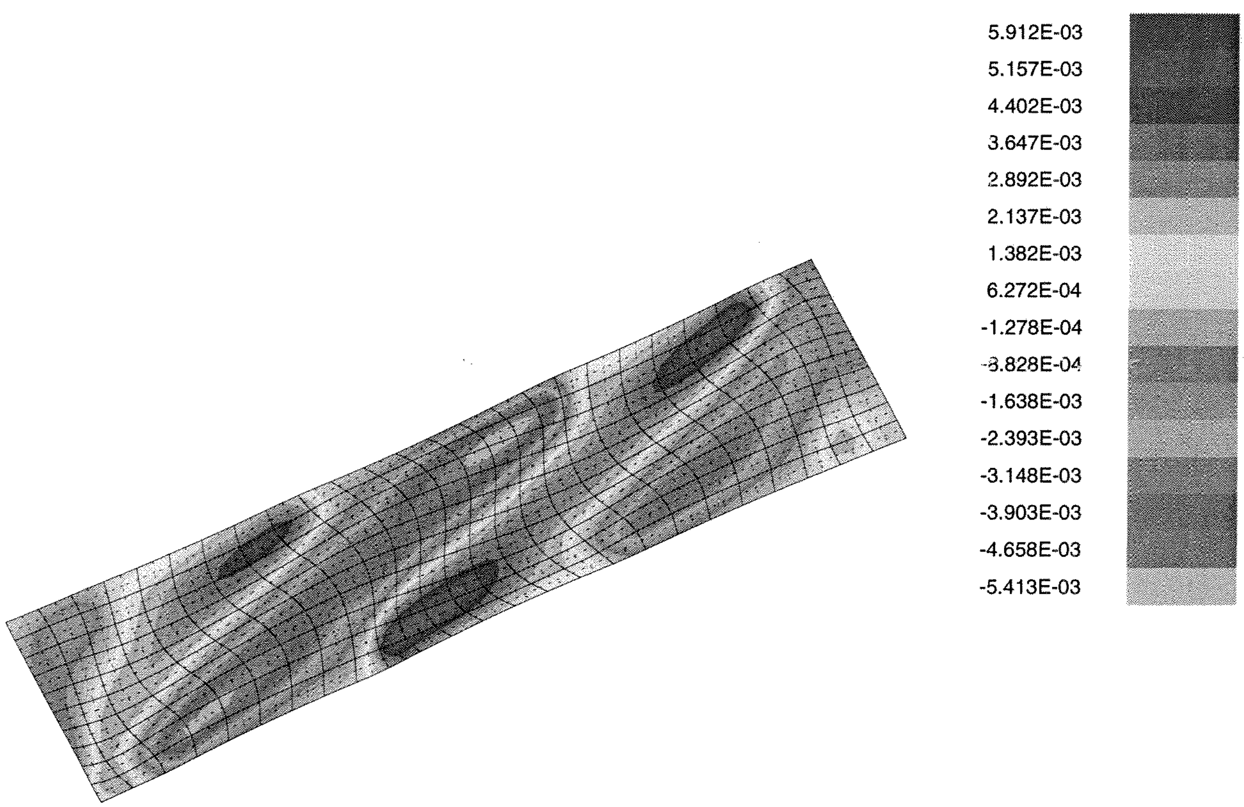
Θ x 24.00
Θ y -22.00
Θ z 30.00

8.957E+00

y
x
z

289

Fig. 2.23



solution scale = 0.4438E+01
PA= 1.00000E+00 PB= 0.00000E+00 PX= 0.00000E+00
step 34 strains , ey, layer 1, outer fiber
nonlinear hoop strain - outer fiber
Minimum value = -5.41292E-03, Maximum value = 5.91233E-03

Θ x 24.00
Θ y -22.00
Θ z 30.00

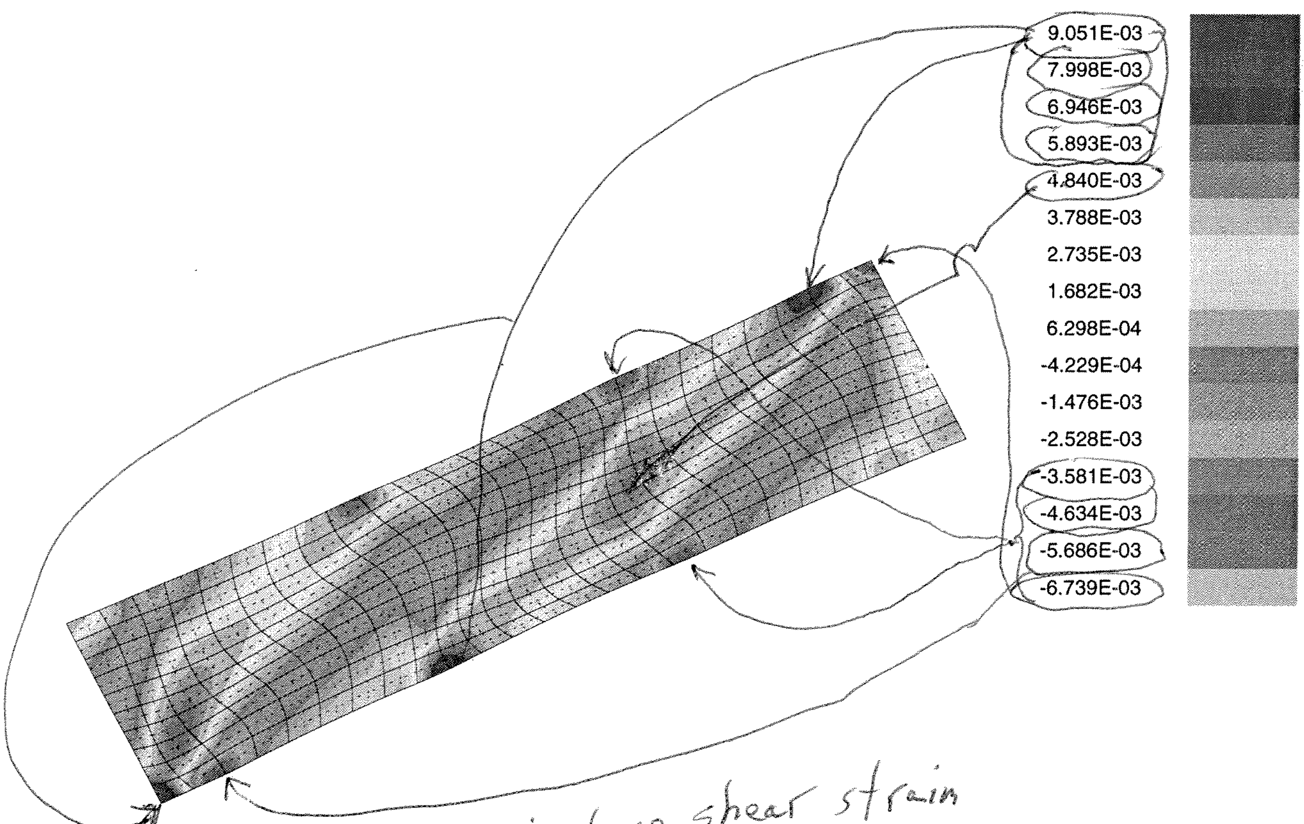
8.957E+00

y x z

290

Fig. 2.24

flat.epsxy.innerfiber.shearload.pdf



in-plane shear strain

solution scale = 0.4438E+01

PA= 1.00000E+00 PB= 0.00000E+00 PX= 0.00000E+00

step 34 strains , exy, layer 1, inner fiber

nonlinear in-plane shear strain - inner fiber

Minimum value = -6.73889E-03, Maximum value = 9.05110E-03

Θ x 24.00
Θ y -22.00
Θ z 30.00

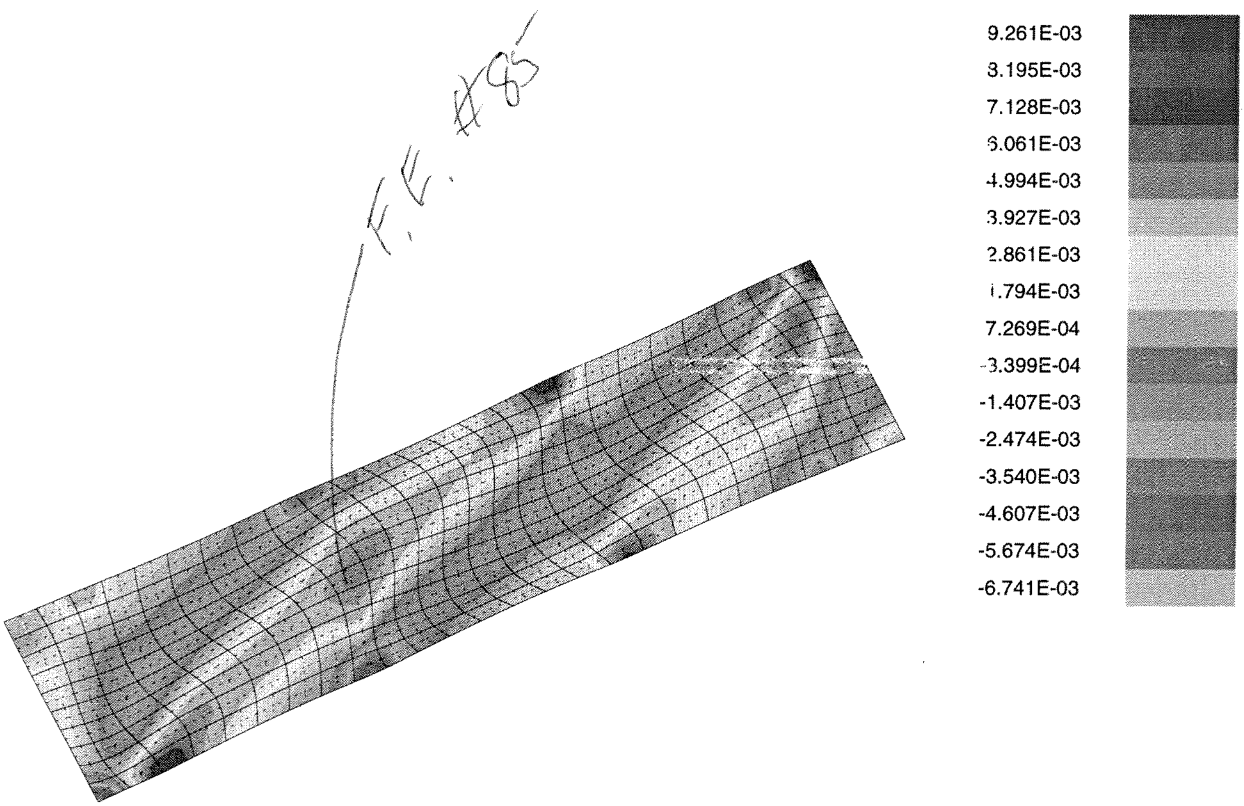
8.957E+00

y x z

291

Fig. 2.25

flat.postbuck.epsxy.outerfiber.shearload.pdf



solution scale = 0.4438E+01
PA= 1.00000E+00 PB= 0.00000E+00 PX= 0.00000E+00
step 34 strains , exy, layer 1, outer fiber
nonlinear in-plane shear strain - outer fiber
Minimum value = -6.74078E-03, Maximum value = 9.26142E-03

Θ x 24.00
Θ y -22.00
Θ z 30.00

8.957E+00

y
x
z

292

Fig. 2.26

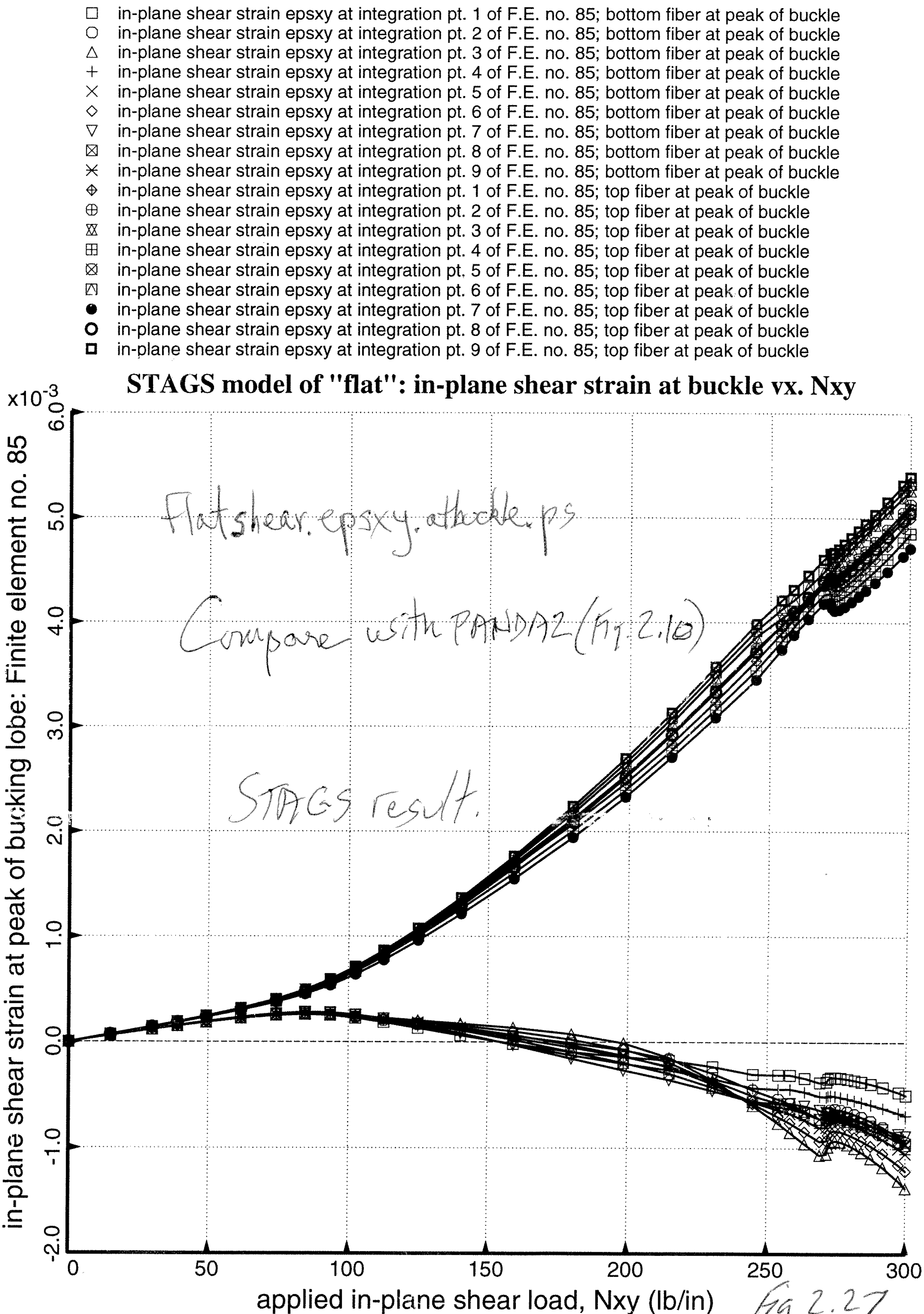

in-plane shear strain epsxy at integration pt. 1 of F.E. no. 85; bottom fiber at peak of buckle
in-plane shear strain epsxy at integration pt. 2 of F.E. no. 85; bottom fiber at peak of buckle
in-plane shear strain epsxy at integration pt. 3 of F.E. no. 85; bottom fiber at peak of buckle
in-plane shear strain epsxy at integration pt. 4 of F.E. no. 85; bottom fiber at peak of buckle
in-plane shear strain epsxy at integration pt. 5 of F.E. no. 85; bottom fiber at peak of buckle
in-plane shear strain epsxy at integration pt. 6 of F.E. no. 85; bottom fiber at peak of buckle
in-plane shear strain epsxy at integration pt. 7 of F.E. no. 85; bottom fiber at peak of buckle
in-plane shear strain epsxy at integration pt. 8 of F.E. no. 85; bottom fiber at peak of buckle
in-plane shear strain epsxy at integration pt. 9 of F.E. no. 85; bottom fiber at peak of buckle
in-plane shear strain epsxy at integration pt. 1 of F.E. no. 85; top fiber at peak of buckle
in-plane shear strain epsxy at integration pt. 2 of F.E. no. 85; top fiber at peak of buckle
in-plane shear strain epsxy at integration pt. 3 of F.E. no. 85; top fiber at peak of buckle
in-plane shear strain epsxy at integration pt. 4 of F.E. no. 85; top fiber at peak of buckle
in-plane shear strain epsxy at integration pt. 5 of F.E. no. 85; top fiber at peak of buckle
in-plane shear strain epsxy at integration pt. 6 of F.E. no. 85; top fiber at peak of buckle
in-plane shear strain epsxy at integration pt. 7 of F.E. no. 85; top fiber at peak of buckle
in-plane shear strain epsxy at integration pt. 8 of F.E. no. 85; top fiber at peak of buckle
in-plane shear strain epsxy at integration pt. 9 of F.E. no. 85; top fiber at peak of buckle
STAGS model of "flat": in-plane shear strain at buckle vx. Nxy
x10-3
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
in-plane shear strain at peak of bucking lobe: Finite element no. 85
flatshear.epsxy.atbuckle.ps
Compare with PANDA2 (Fig. 2.10)
STAGS result.
0
50
100
150
200
250
300
applied in-plane shear load, Nxy (lb/in)

Fig. 2.27