Table 1.51   riks.itype3.1.cpl = riks.CPL

```
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
  1   $ 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)?
n     $ Any extreme fiber strains to be plotted v. load steps?
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,..)
y     $ Any more margins to be plotted (Y or N) ?
  8   $ Choose a margin to be plotted v. iterations (1,2,3,..)
y     $ Any more margins to be plotted (Y or N) ?
  9   $ Choose a margin to be plotted v. iterations (1,2,3,..)
y     $ Any more margins to be plotted (Y or N) ?
 10   $ Choose a margin to be plotted v. iterations (1,2,3,..)
y     $ Any more margins to be plotted (Y or N) ?
 11   $ Choose a margin to be plotted v. iterations (1,2,3,..)
y     $ Any more margins to be plotted (Y or N) ?
 12   $ Choose a margin to be plotted v. iterations (1,2,3,..)
y     $ Any more margins to be plotted (Y or N) ?
 13   $ Choose a margin to be plotted v. iterations (1,2,3,..)
y     $ Any more margins to be plotted (Y or N) ?
 14   $ Choose a margin to be plotted v. iterations (1,2,3,..)
y     $ Any more margins to be plotted (Y or N) ?
 15   $ Choose a margin to be plotted v. iterations (1,2,3,..)
n     $ Any more margins to be plotted (Y or N) ?
  3   $ Give maximum value (positive) to be included in plot frame.
y     $ Any deformed panel module cross sections to be plotted?
  0   $ 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)?
 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)?
 15   $ 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)?
```

input to CHOOSEPLOT

output from DIPLOT

riks.itype3.margins.ps = riks.3.ps

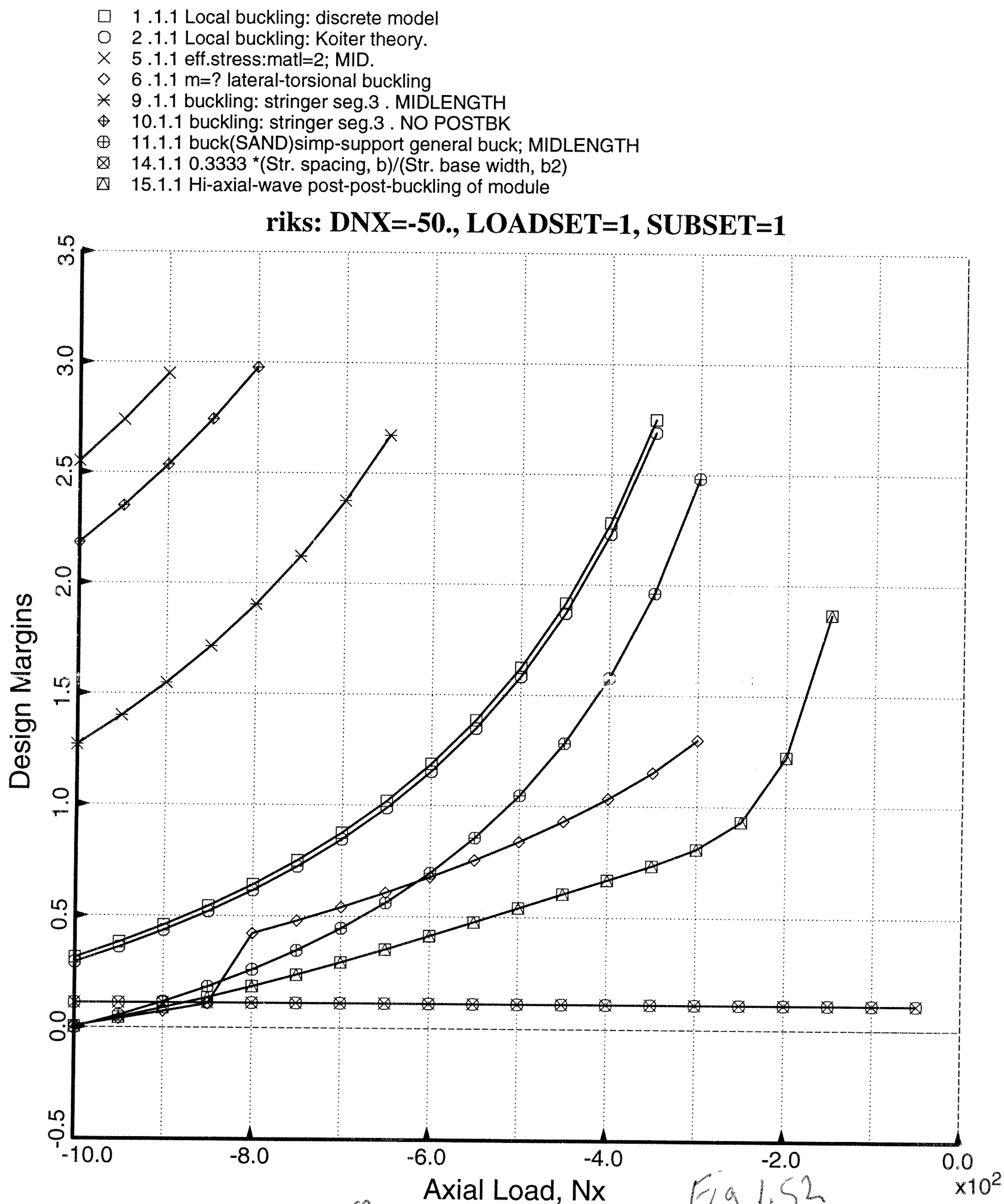

Fig. 1.52

output from DIPLOT

riks.itype3.w.ps = riks.4.ps

□ 2 .1.1 Max.disp.w in panel module, w(max)=Wimplocal+Wpostbuck+Wpillow

riks: DNX=-50., LOADSET=1, SUBSET=1

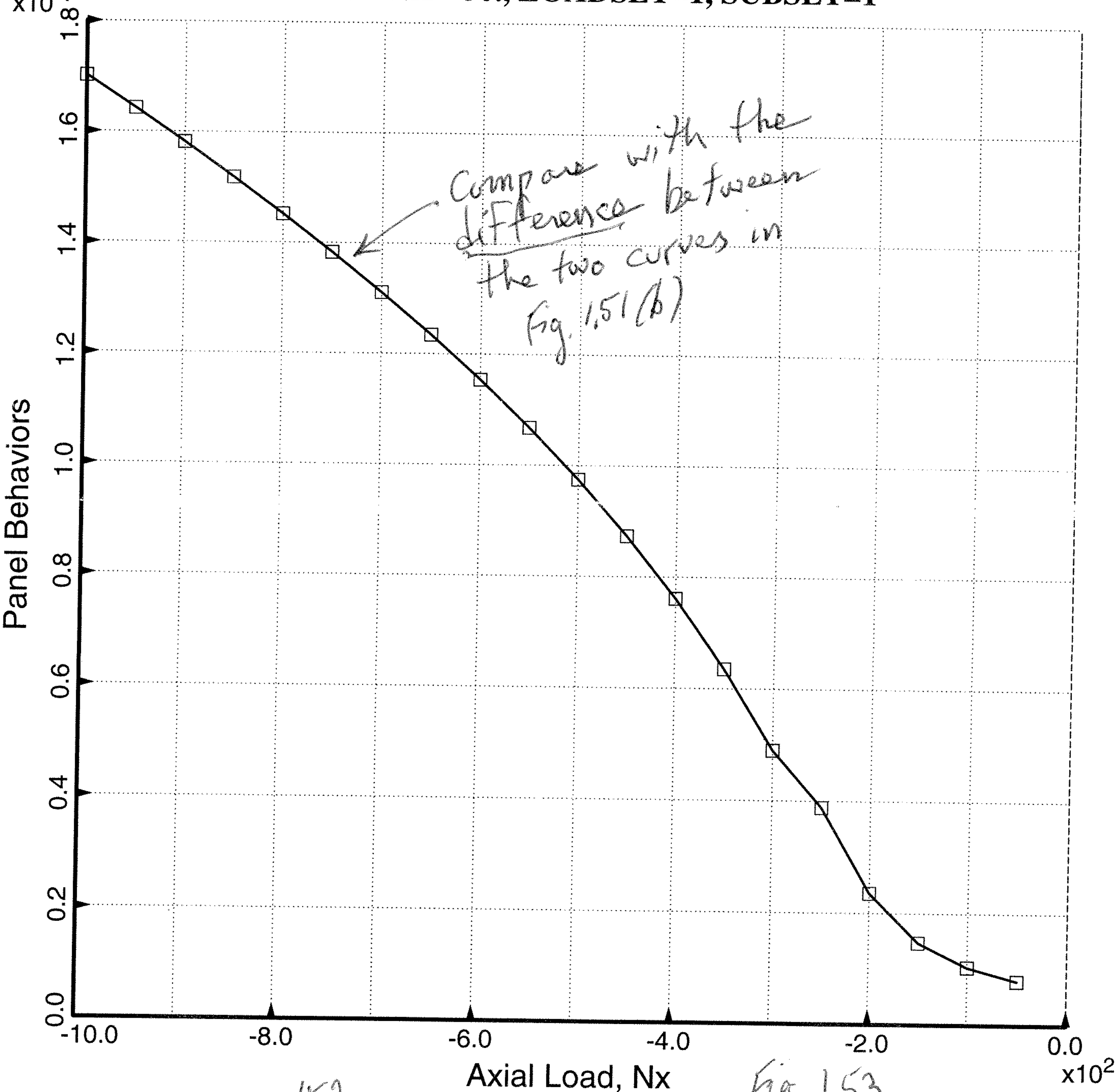

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Fig. 1.53

output from DIPLOT

riks.itype3.module.ps = riks.5.ps

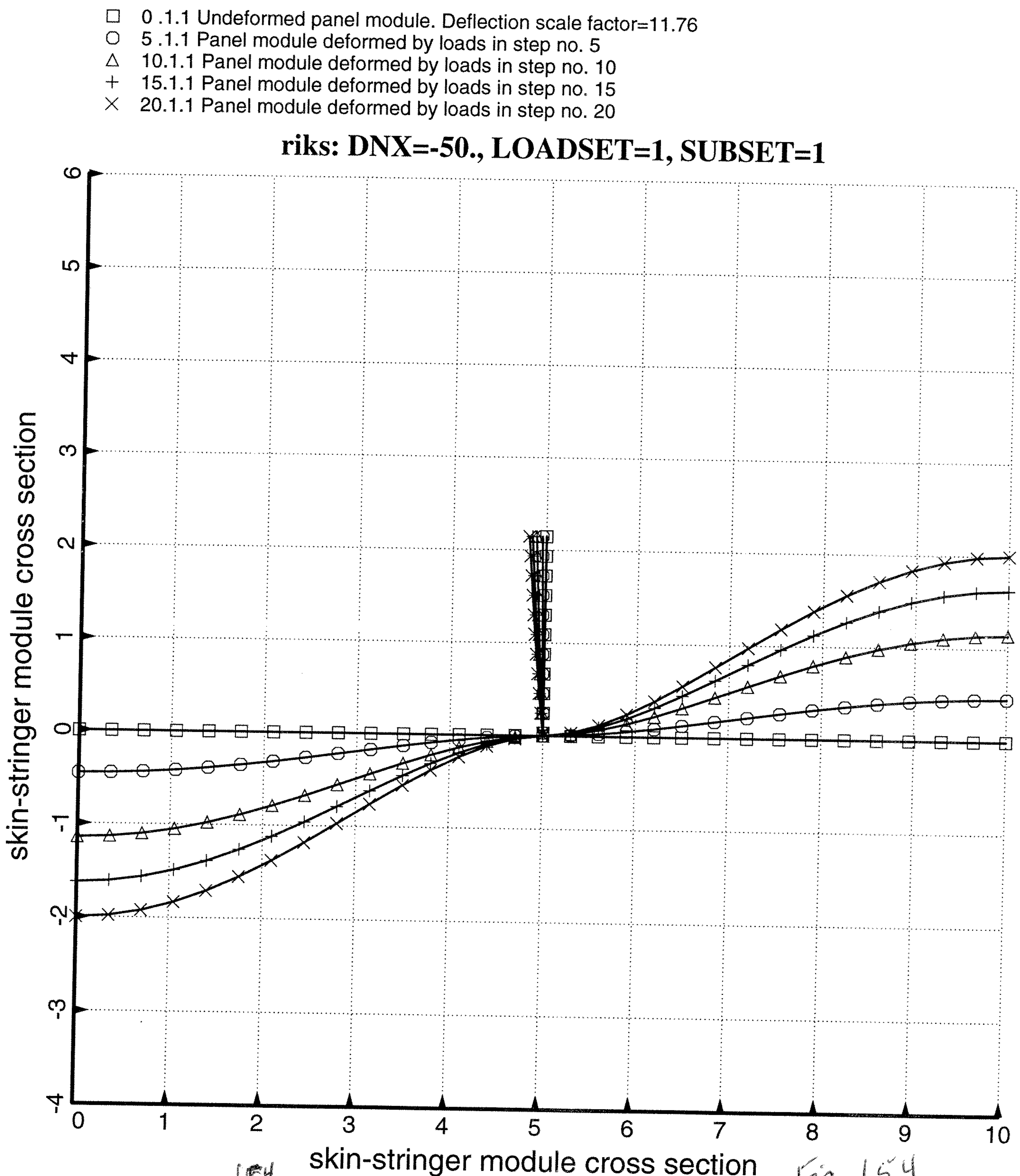

Fig. 1.54

output from DIPLOT

riks.itype3.3D.ps = riks.7.ps

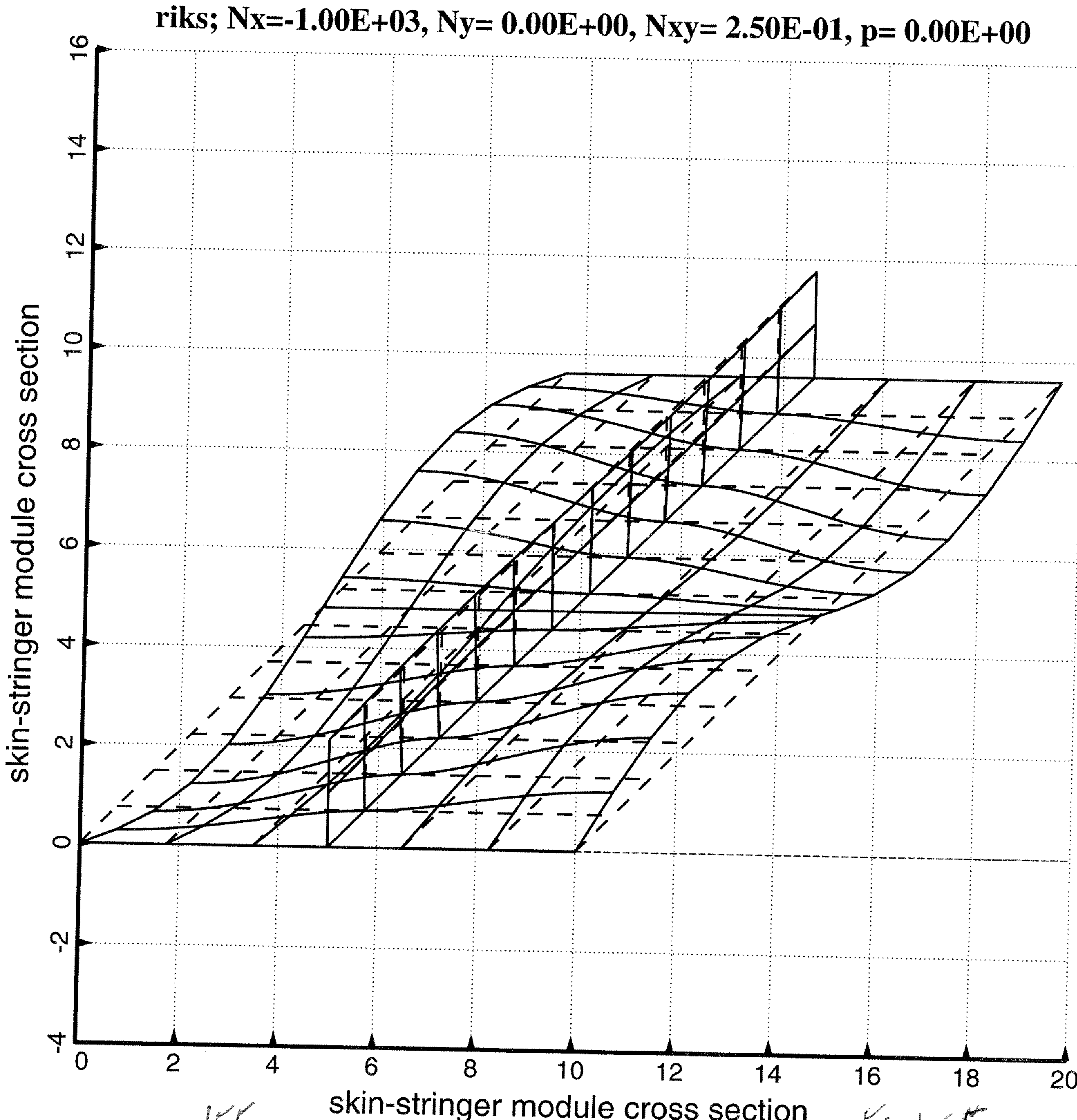

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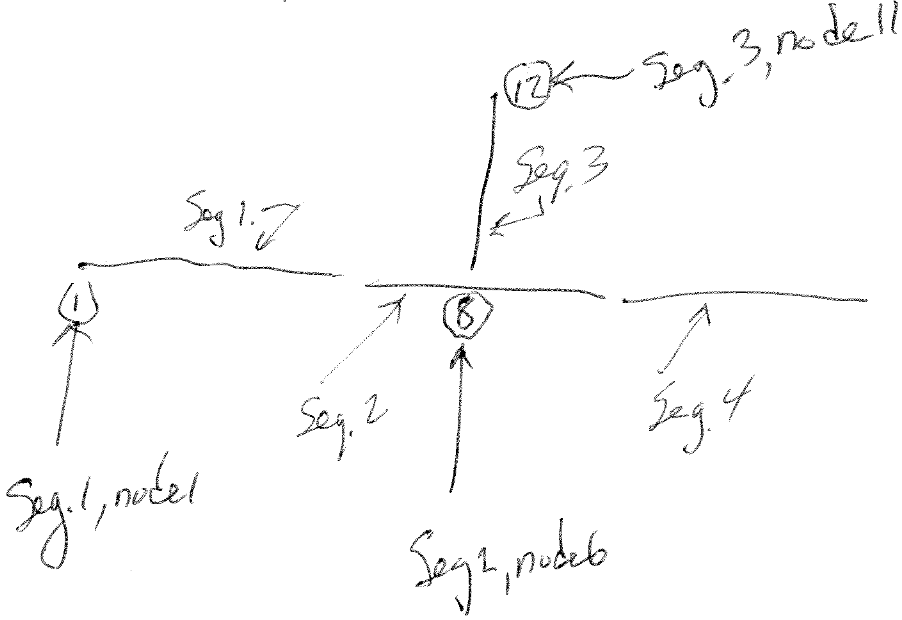
Fig. 1.55

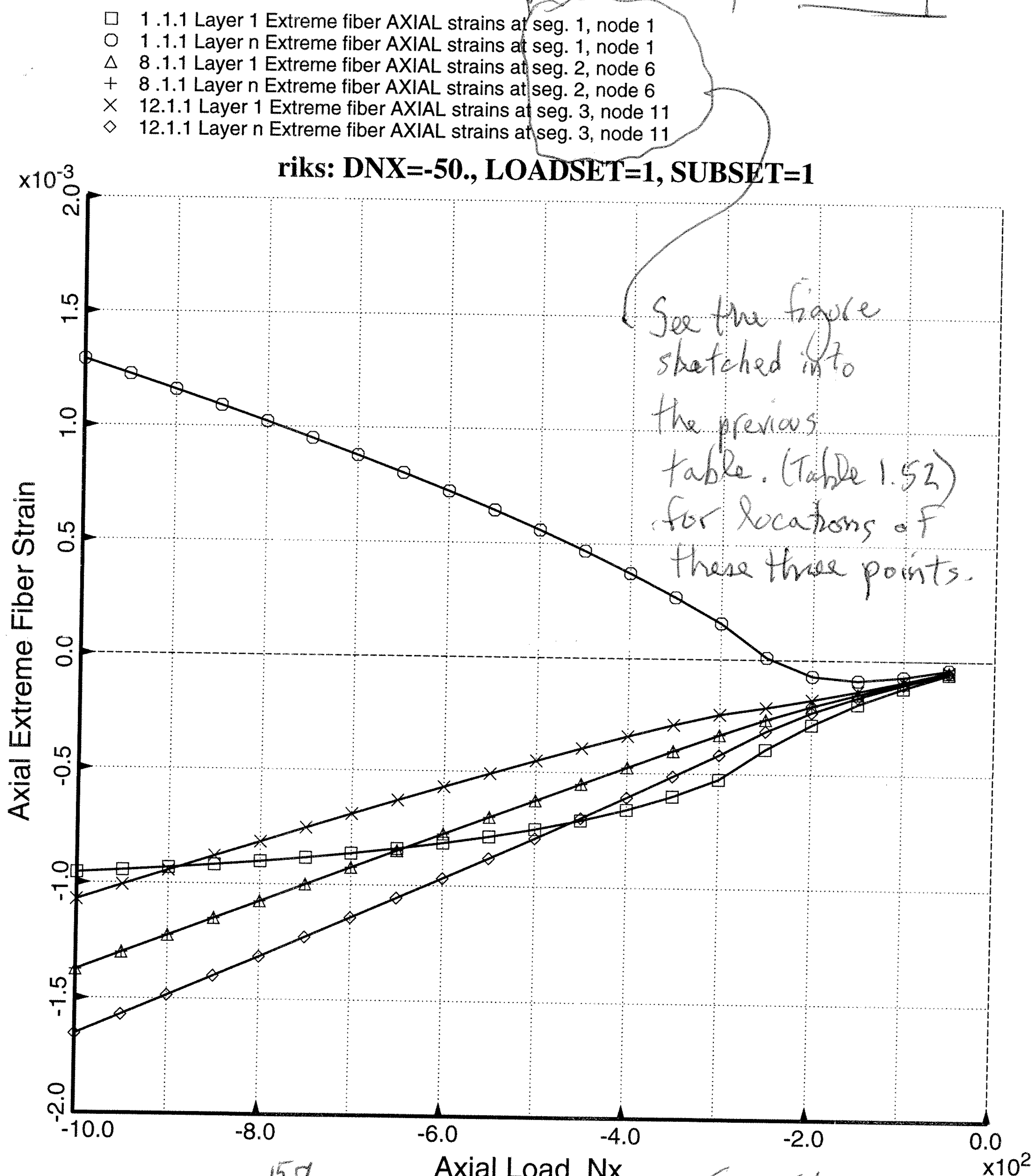
Table 1.52 riks.itype4.2.cpl = riks.CPL

```
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
   1       $ Indicate which load component to use in plots (1,2,...7)
n          $ Any behaviors to be plotted v. load steps (Y or 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)?
   8       $ Choose a location (1, 2, ...) for strain plots
y          $ Any more locations for plotting v. load steps (Y/N)?
  12       $ Choose a location (1, 2, ...) for strain plots
n          $ Any more locations for plotting v. load steps (Y/N)?
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)?
```

input to CHOOSEPLOT



output from DIPLOT
riks.itype3.axialstrain.ps = riks.8.ps



See the figure sketched into the previous table. (Table 1.52) for locations of these three points.

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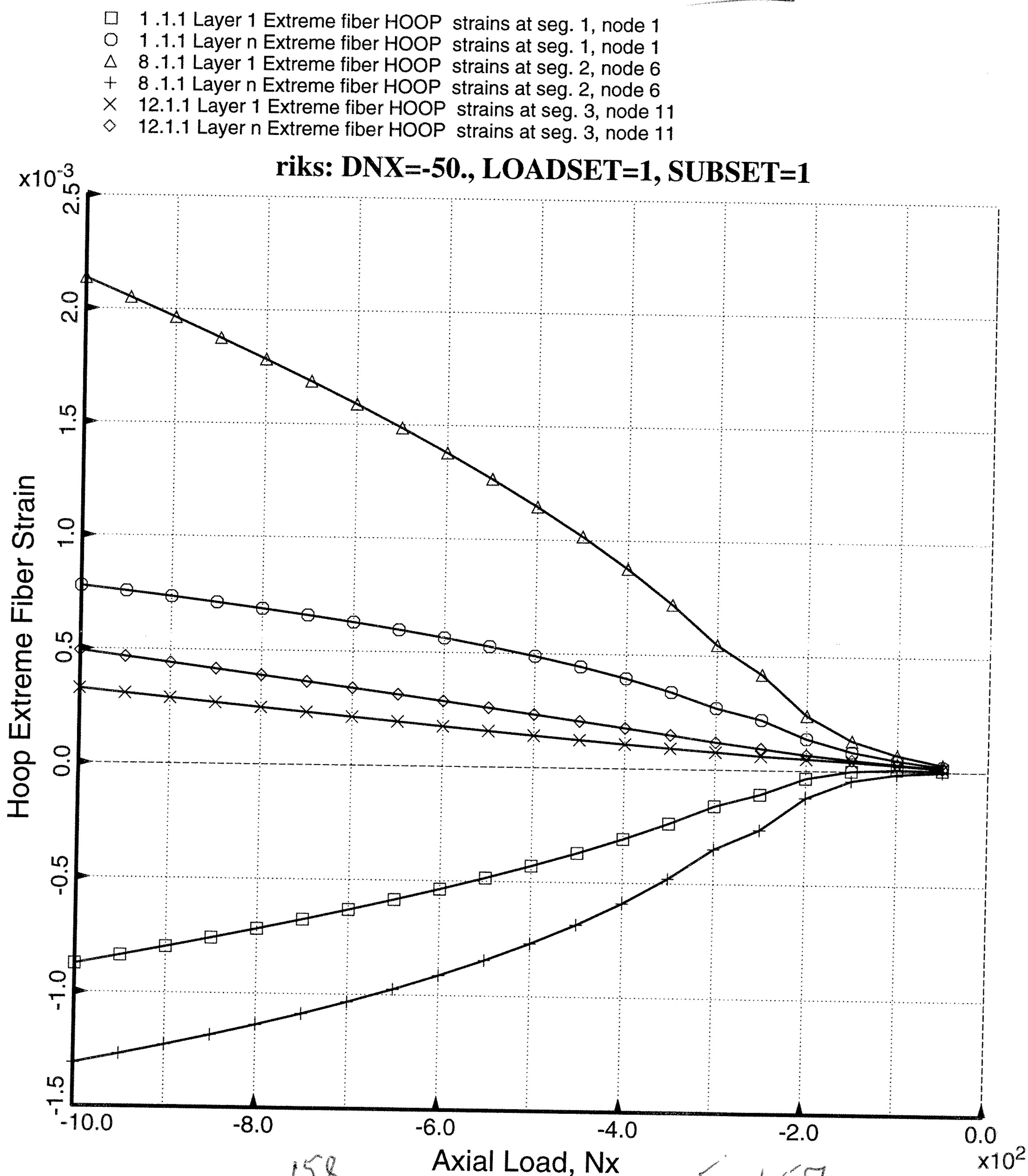
Fig. 1.56

output from DIPLOT

riks.itype3.hoopstrain.ps = riks.9.ps

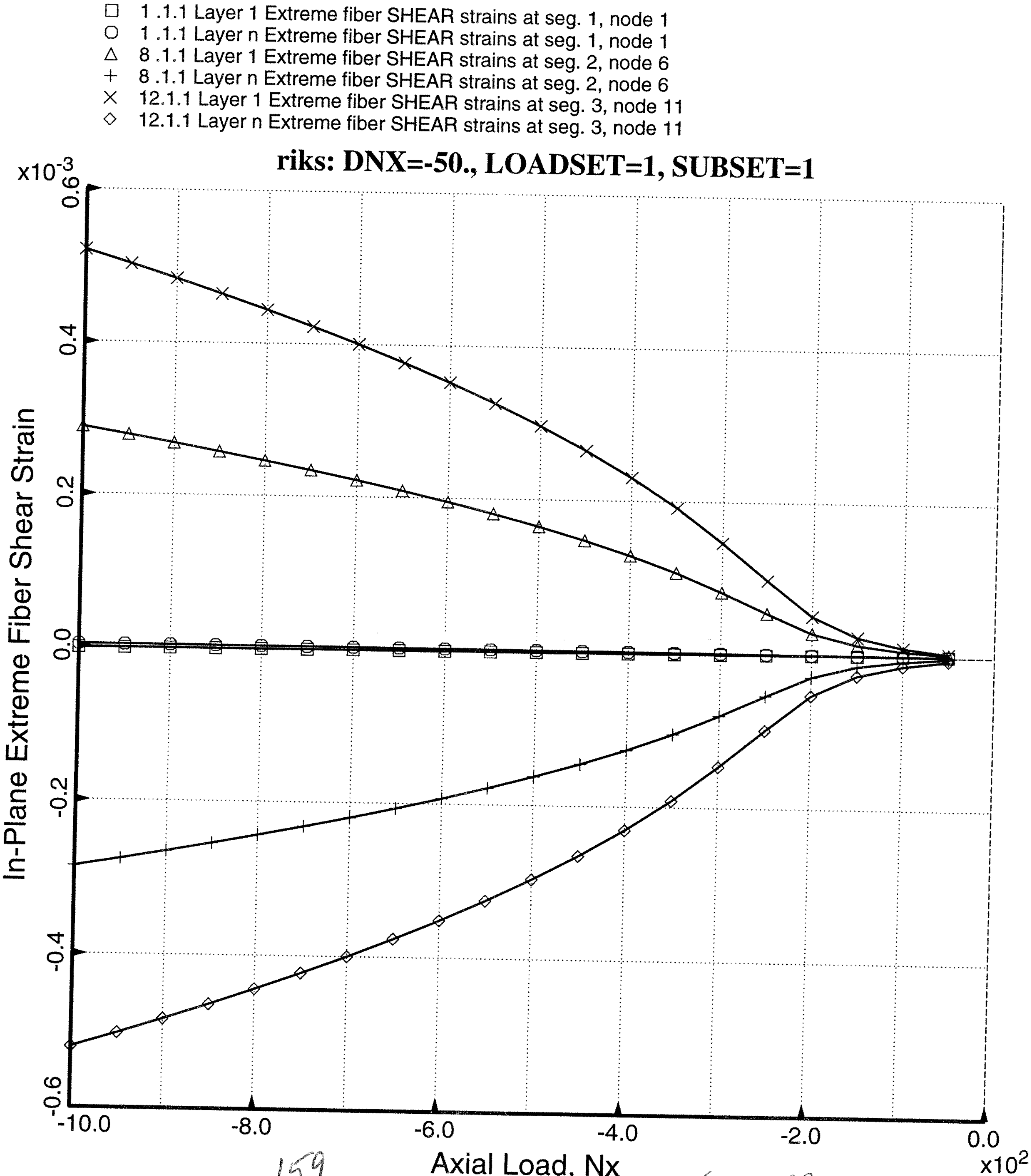


158

Fig. 1.57

output from DIPLOT

riks.itypes.shearstrain.ps = riks.10.ps



159

Fig. 1.58

riks.PAN

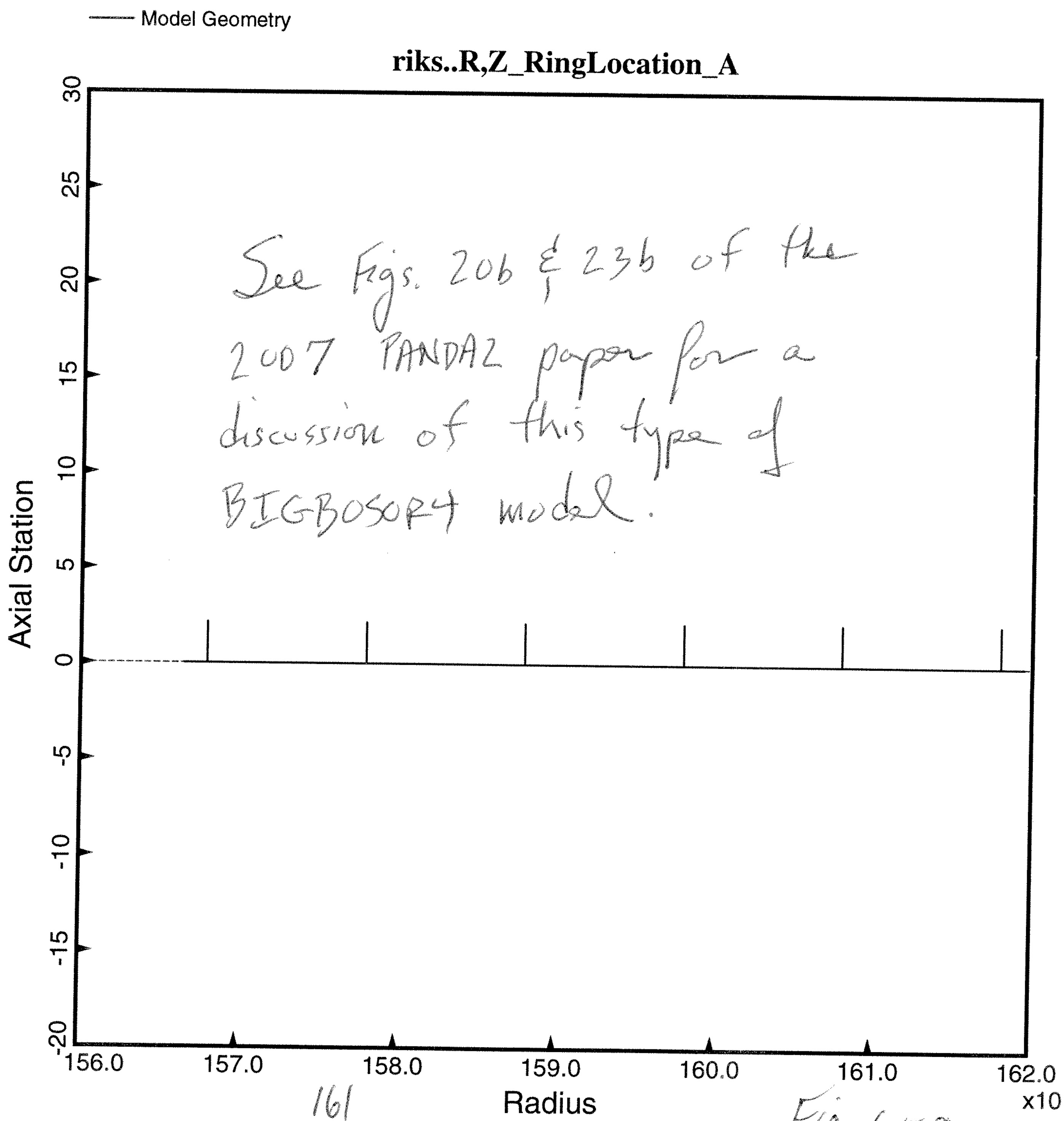
Table ~~1.49~~ 1.53

```
      n          $ Do you want a tutorial session and tutorial output?
50.00000         $ Panel length in the plane of the screen, L2
      1          $ Enter control (0 or 1) for stringers at panel edges
      1          $ Enter ILOCAL=0 for panel buckling; 1 for local buckling, ILOCAL
      7          $ Number of halfwaves in the axial direction [see H(elp)],NWAVE
      3          $ How many eigenvalues (get at least 3) do you want?
```

See Table 1.35. Also the definitions of Margins No. 1 in Table 1.45

riks.realstiff.bigbosor4.undeformed.ps

output from BIGBOSOR4



See Figs. 20b & 23b of the 2007 PANDA2 paper for a discussion of this type of BIGBOSOR4 model.

Fig. 1.59

riks.realstiff.bigbosor4.bucklingmode.ps

output from ~~Bosor~~ BIGBOSOR4

BIGBOSOR4

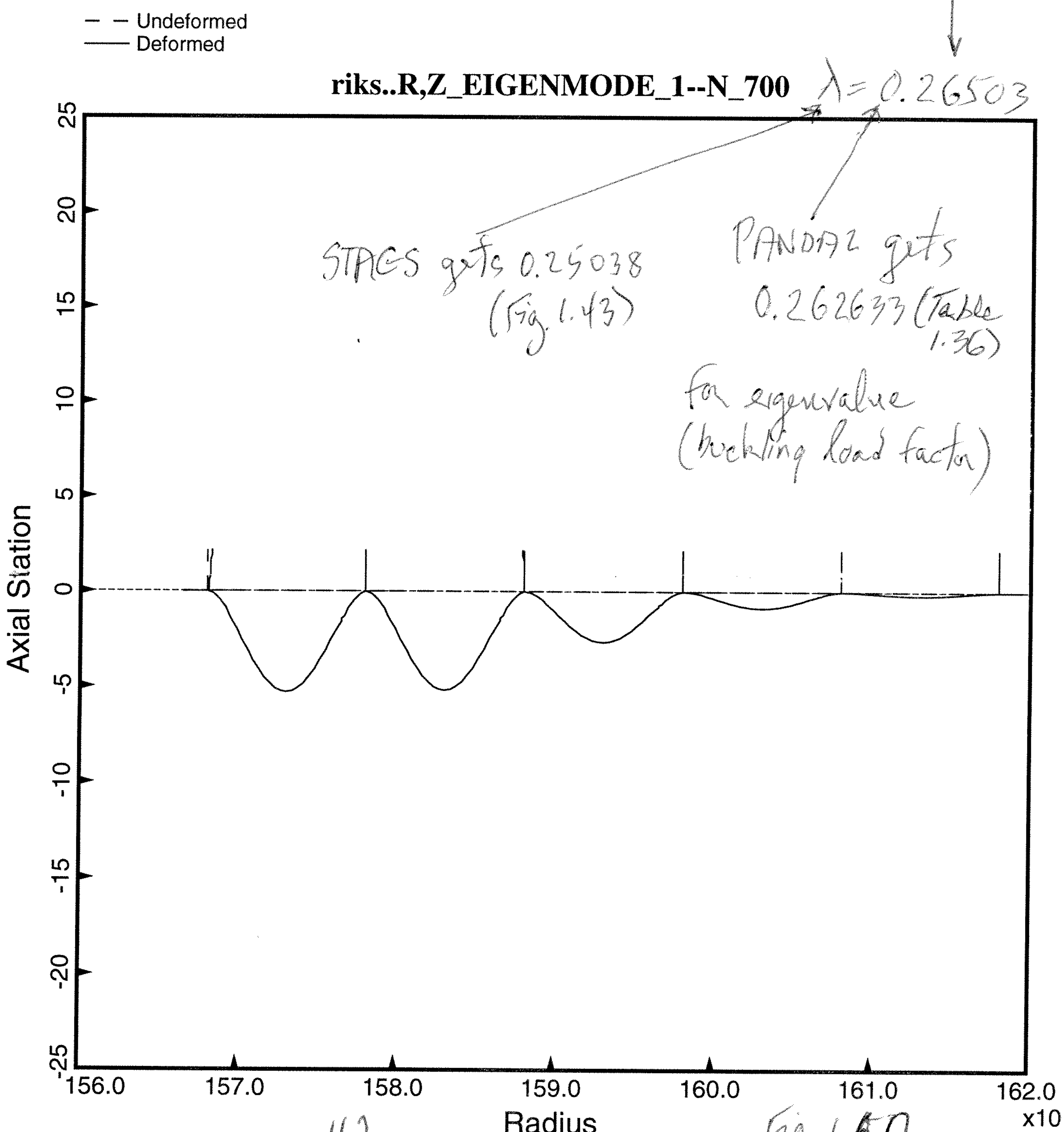


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Fig. 1.60

Table 1.54

riks.superopt.runstream

10 July, 2008

Example 3.2

This runstream is similar to that listed in Table 1.27 except things here the PANDA2 processor, SUPEROPT, is used to obtain the optimum design and things are done in a slightly different order and only the in-plane "rigid" longitudinal edge option is used for the STAGS model.

This runstream is for the optimization, analysis, and verification of a flat panel with axially oriented rectangular stiffeners (stringers). the desision variables are: skin thickness, stringer thickness, and stringer height. The stringer spacing is held constant at 10 inches.

NOTE:
In this case the factor of safety for local buckling is 0.5 instead of 0.2. Therefore, the panel is optimized for a condition in which it is loaded LESS FAR into the post-local buckling regime than is the case for the previous results for which the factor of safety for local buckling was 0.2.

Note

Several things are done:

1. The panel is first optimized via SUPEROPT by PANDA2 (analysis type ITYPE = 1).

2. Results are then obtained by PANDA2 running in the "fixed design analysis branch" (analysis type ITYPE = 2 for the optimum design).

3. The PANDA2 processor called CHANGE is used to save the optimized design previously obtained by PANDA2 in Item 1, and PANDA2 is then run in a "test simulation" mode, that is, analysis type ITYPE = 3.

4. Linear bifurcation buckling and nonlinear equilibrium STAGS runs are then executed. Input files, *.bin and *.inp, for STAGS are generated via the PANDA2 processor called STAGSUNIT.

5. A BIGBOSOR4 model of local buckling is then derived via the PANDA2 processor called PANEL and BIGBOSOR4 is executed.

The case is called "riks" and the loading is pure axial compression, Nx = -1000 lb/in.

```
panda2log
begin          (cp riks.realstiff.beg riks.BEG; input = riks.BEG = Table 1.28)
setup
decide         (cp riks.realstiff.dec riks.DEC; input = riks.DEC = Table 1.29)
mainsetup      (input = riks.OPT = Table 1.55(a), ITYPE=1)
superopt       (optimize to get the "global" optimum design) <--NOTE THE USE OF SUPEROPT
chooseplot     (input = riks.CPL = Table 1.55(b))
diplot
cp riks.5.ps riks.superopt.ps = Fig. 1.61
mainsetup      (change ITYPE to 2, analysis of fixed design; input = riks.OPT = Table 156.
pandaopt       (analyze the fixed design, which is the optimum design.) (See Tables 1.57)

(Next, run PANDA2 with the ITYPE = 3 analysis type, that is, in the
 "test simulation" mode.)

(First use CHANGE to save the optimum design)
change         (Input = riks.CHG = Table 1.58)
setup          (PANDA2 gets matrix templates.)
mainsetup      (Input = riks.OPT = Table 1.59)
pandaopt       (PANDA2 is run in "test simulation" mode, that is, ITYPE=3)
chooseplot     (user chooses what to plot vs applied load.
                Input = riks.CPL = Table 1.60)
diplot         (generate postscript files, riks.3.ps, riks.4.ps, riks.5.ps,
                and riks.7.ps. See Figs. 1.61, 1.62, 1.63, 1.64, respectively)

(Next, use STAGS to evaluate the optimized panel.)

stagsunit      (input is riks.STG listed in Table 1.61. This riks.STG file
                is valid for linear bifurcation buckling)

(Run STAGS to get linear buckling mode, shown in Fig. 1.65.)

stagsunit      (input is riks.STG listed in Table 1.62. This riks.STG file
                is valid for nonlinear equilibrium of an imperfect shell
                with one buckling modal imperfection with amplitude=0.01 inch)
```

(Run STAGS to get nonlinear behavior of imperfect shell shown in Figs. 1.66 - 1.70)

(The use of STAGS is described in several recent PANDA2 papers.
Briefly, one first runs a linear buckling analysis (INDIC=1) with STAGS
in order to obtain a buckling modal imperfection shape suitable
for use as an initial imperfection. Then one runs a nonlinear
equilibrium analysis (INDIC=3) of the shell or panel with its buckling
modal imperfection shape with user-specified amplitude in
order to find the load-bearing capability of the imperfect structure..
No further description of how to do this will be given here.
See the recent PANDA2 papers for more details.)

(Next, generate input data valid for BIGBOSOR4 for checking local buckling)

```
panel            (set up input file, riks.ALL, for BIGBOSOR4 procssor
                  called BIGBOSORALL. The input file for PANEL is called riks.PAN =
                  Table 1.63. The output file from PANEL is called riks.ALL .)

(go to directory where you want to run BIGBOSOR4. Copy riks.ALL there. )
bigbosor4log     (activate the BIGBOSOR4 commands)
bigbosorall      (run BIGBOSOR4. Search the riks.OUT file for the string,
                  "EIGENVALUE("  )
bosorplot        (get plot of the critical (lowest eigenvalue) buckling mode.
                  see Fig. 1.71 for the buckling mode from BIGBOSOR4.)
cleanup
```

Table 1.55(a) riks.OPT (input for MAINSETUP)

```
       n          $ Do you want a tutorial session and tutorial output?
  -1000.          $ 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)
        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?
 1.0000000        $ Factor of safety for general instability, FSGEN( 1)
 0.5000000        $ 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)
  0.000000        $ 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
        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)
```

Note →

Was 0.2 in previous ~~analysis~~ design & analysis

optimization

Table 1.55(b) riks.CPL (input for CHOOSEPLOT)

```
n       $ Do you want a tutorial session and tutorial output?
n       $ Any design variables to be plotted v. iterations (Y or N)?
n       $ Any design margins to be plotted (Y or N)?
y       $ Do you want a plot of the objective v. iterations (Y/N)?
n       $ Do you want to get more plots before your next "SUPEROPT"?
```

riks.5.ps

output from DIPLOT,
Results from "SUPEROPT" run

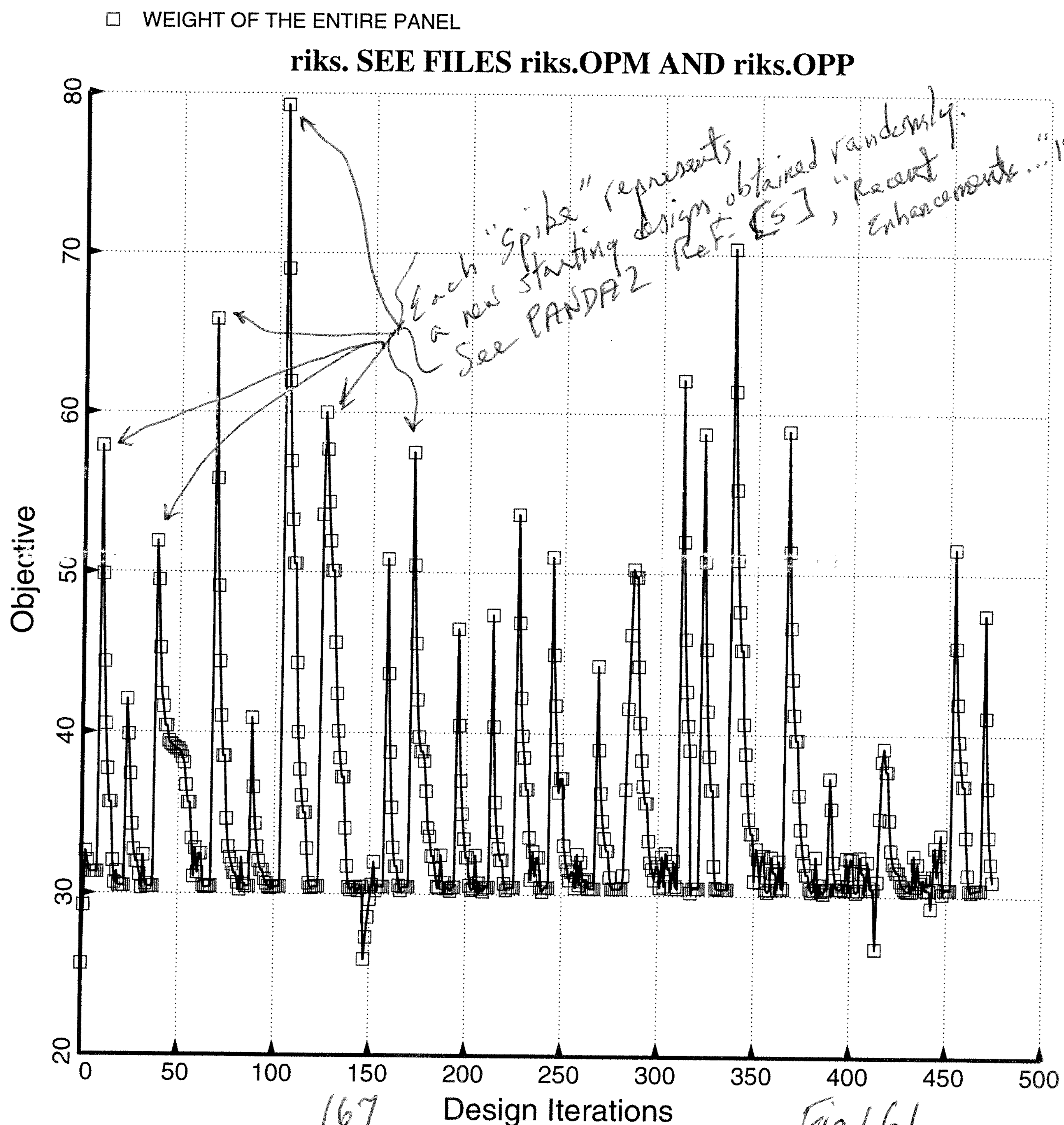


Fig 1.61

Table 1.56 riks.OPT (input for MAINSETUP)

```
    n          $ Do you want a tutorial session and tutorial output?
 -1000.        $ 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)
      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?
 1.0000000     $ Factor of safety for general instability, FSGEN( 1)
note → 0.5000000  $ 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)
 0.000000      $ 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
      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)
```

fixed design

Table 1.57 Abridged riks.OPM file, analogous to Table 1.45 for the earlier optimum design

riks.OPM (abridged)

```
 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

 ANALYSIS: ITYPE=2;  IQUICK=0;  LOAD SET 1;  SUBCASE 1:
 LOADING: Nx, Ny, Nxy, Mx, My =  -1.00E+03  0.00E+00  5.00E+00  0.00E+00  0.00E+00
          Nxo, Nyo, pressure  =   0.00E+00  0.00E+00  0.00E+00
 BUCKLING LOAD FACTORS FOR LOCAL BUCKLING FROM KOITER v. BOSOR4 THEORY:
  Local buckling load factor from KOITER theory = 4.8778E-01 (flat skin)
  Local buckling load factor from BOSOR4 theory = 4.9137E-01 (flat skin)
0
 MARGINS FOR CURRENT DESIGN: LOAD CASE NO. 1, SUBCASE NO. 1
 MAR. MARGIN
 NO.  VALUE                DEFINITION
 1 -1.65E-02 Local buckling from discrete model-1.,M=6   axial halfwaves;FS=0.5
 2 -2.44E-02 Local buckling from Koiter theory,M=6   axial halfwaves;FS=0.5
 3  4.81E+01 eff.stress:matl=1,SKN,Dseg=2,node=6,layer=1,z=0.0429; MID.;FS=1.
 4  8.69E+03 stringer popoff margin:(allowable/actual)-1, web 1  MID.;FS=1.
 5  2.30E+00 eff.stress:matl=2,STR,Dseg=3,node=11,layer=1,z=0.0879; MID.;FS=1.
 6  4.14E-01 Hi-axial-wave post-post-buckling of module - 1;   M=12 ;FS=1.
 7  7.87E-02 (m=3   lateral-torsional buckling load factor)/(FS)-1;FS=1.1
 8  8.14E+01 eff.stress:matl=1,SKN,Iseg=1,allnode,layer=1,z=-0.0429;-MID.;FS=1.
 9  6.25E+00 eff.stress:matl=2,STR,Iseg=3,at:TIP,layer=1,z=0.;-MID.;FS=1.
10  1.89E+00 buckling margin stringer Iseg.3 . Local halfwaves=5  .MID.;FS=1.
11  2.93E+00 buckling margin stringer Iseg.3 . Local halfwaves=5  .NOPO;FS=1.
12 -1.16E-02 buck.(DONL);simp-support general buck;M=1;N=1;slope=0.;FS=1.1
13  4.75E+00 buck.(DONL);rolling only of stringers;M=16;N=0;slope=0.;FS=1.4
14  8.53E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
15  1.11E-01 0.3333 *(Stringer spacing, b)/(Stringer base width, b2)-1;FS=1.
16 -1.16E-02 buck.(SAND);simp-support general buck;M=1;N=1;slope=0.;FS=1.1
 ***********  ALL 1 LOAD SETS PROCESSED  ***********
 ****************************************************
```

BIGBOSOR4 gets 0.501

compare with STAGS = 0.478

compare with stags (Fig. 1.65)

note. Compare with Table 1.45

optimum design from SUPEROPT

```
0
          SUMMARY OF INFORMATION FROM OPTIMIZATION ANALYSIS
 VAR. DEC. ESCAPE LINK. LINKED  LINKING    LOWER     CURRENT     UPPER        DEFINITION
  NO. VAR.  VAR.  VAR.    TO   CONSTANT    BOUND      VALUE      BOUND
   1   N     N     N      0    0.00E+00  0.00E+00  1.0000E+01  0.00E+00      B(STR):stiffener s»
pacing, b: STR seg=NA, layer=NA
   2   N     N     N      0    0.00E+00  0.00E+00  3.0000E+00  0.00E+00      B2(STR):width of st»
ringer base, b2 (must be > 0, see
   3   Y     N     N      0    0.00E+00  2.00E-01  1.9893E+00  1.00E+01      H(STR):height of s»
tiffener (type H for sketch), h:
   4   Y     Y     N      0    0.00E+00  1.00E-02  8.5817E-02  1.00E+00     T(1 )(SKN):thickness f»
or layer index no.(1 ): SKN seg=1
   5   Y     Y     N      0    0.00E+00  1.00E-02  1.7586E-01  1.00E+00     T(2 )(STR):thickness f»
or layer index no.(2 ): STR seg=3
0
   CURRENT VALUE OF THE OBJECTIVE FUNCTION:
 VAR. STR/ SEG. LAYER    CURRENT
 NO.  RNG  NO.   NO.      VALUE            DEFINITION
            0     0    3.020E+01   WEIGHT OF THE ENTIRE PANEL

  TOTAL WEIGHT OF SKIN                              =    2.1454E+01
  TOTAL WEIGHT OF SUBSTIFFENERS                     =    0.0000E+00
  TOTAL WEIGHT OF STRINGERS                         =    8.7464E+00
  TOTAL WEIGHT OF RINGS                             =    0.0000E+00
  SPECIFIC WEIGHT (WEIGHT/AREA) OF STIFFENED PANEL=    1.2080E-02
 IN ORDER TO AVOID FALSE CONVERGENCE OF THE DESIGN, BE SURE TO
 RUN  PANDAOPT  MANY TIMES DURING AN OPTIMIZATION. INSPECT THE
 riks.OPP  FILE AFTER EACH OPTIMIZATION RUN. OR BETTER YET,
 RUN SUPEROPT.
 ******************** END OF riks.OPM FILE ****************
```

Table 1.58

riks.CHG (riks.localbuck0.5.chg)

```
       n          $ Do you want a tutorial session and tutorial output?
       y          $ Do you want to change any values in Parameter Set No. 1?
          3       $ Number of parameter to change (1, 2, 3, . .)
   1.989300       $ New value of the parameter
       y          $ Want to change any other parameters in this set?
          4       $ Number of parameter to change (1, 2, 3, . .)
 0.8581700E-01    $ New value of the parameter
       y          $ Want to change any other parameters in this set?
          5       $ Number of parameter to change (1, 2, 3, . .)
 0.1758600        $ 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?
```

stif. height
skin thickness
stiffener thickness

input for CHANGE

This is a good way to save the optimum design.

Table 1.59 riks.OPT (input for MAINSETUP for ITYPE=3)

```
        n     $ Do you want a tutorial session and tutorial output?
  -50.000     $ 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)
        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?
1.0000000     $ Factor of safety for general instability, FSGEN( 1)
0.5000000     $ 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)
 0.000000     $ 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)
        1     $ 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
        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
-50.00000     $ Increment in axial resultant Nx:  DNX
        0     $ Increment in hoop resultant Ny:  DNY
        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
```

note (beside 0.5000000)

note (beside 3, ITYPE)

test simulation type of analysis

Table 1.60 riks.CPL (input for CHOOSEPLOT)

```
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
    1      $ 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)?
n          $ Any extreme fiber strains to be plotted v. load steps?
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,..)
y          $ Any more margins to be plotted (Y or N) ?
    8      $ Choose a margin to be plotted v. iterations (1,2,3,..)
y          $ Any more margins to be plotted (Y or N) ?
    9      $ Choose a margin to be plotted v. iterations (1,2,3,..)
y          $ Any more margins to be plotted (Y or N) ?
   10      $ Choose a margin to be plotted v. iterations (1,2,3,..)
y          $ Any more margins to be plotted (Y or N) ?
   11      $ Choose a margin to be plotted v. iterations (1,2,3,..)
y          $ Any more margins to be plotted (Y or N) ?
   12      $ Choose a margin to be plotted v. iterations (1,2,3,..)
y          $ Any more margins to be plotted (Y or N) ?
   13      $ Choose a margin to be plotted v. iterations (1,2,3,..)
y          $ Any more margins to be plotted (Y or N) ?
   14      $ Choose a margin to be plotted v. iterations (1,2,3,..)
y          $ Any more margins to be plotted (Y or N) ?
   15      $ Choose a margin to be plotted v. iterations (1,2,3,..)
n          $ Any more margins to be plotted (Y or N) ?
    3      $ Give maximum value (positive) to be included in plot frame.
y          $ Any deformed panel module cross sections to be plotted?
    0      $ 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)?
   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)?
   15      $ 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)?
```

riks.3.ps (output from DIPLOT)

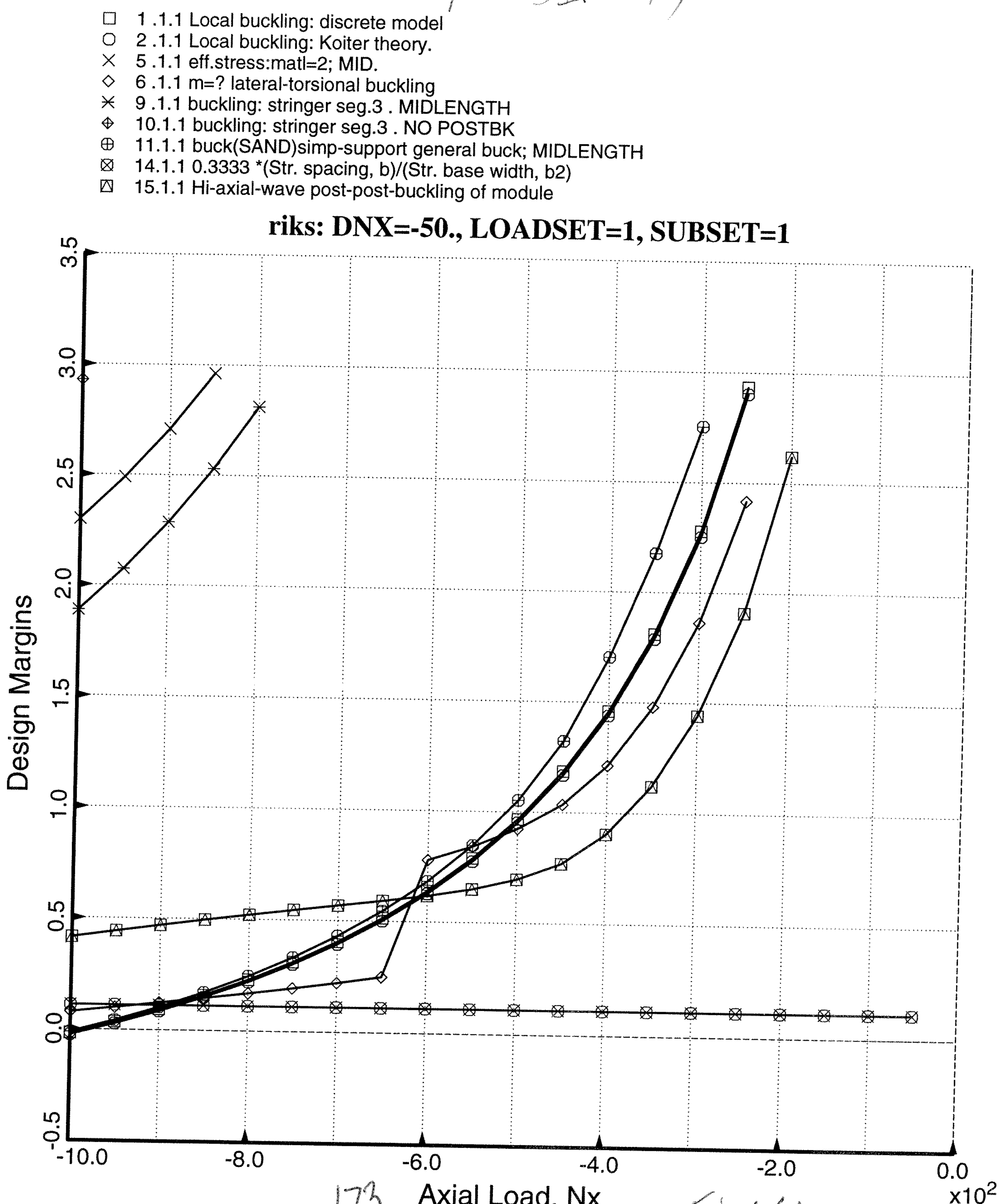
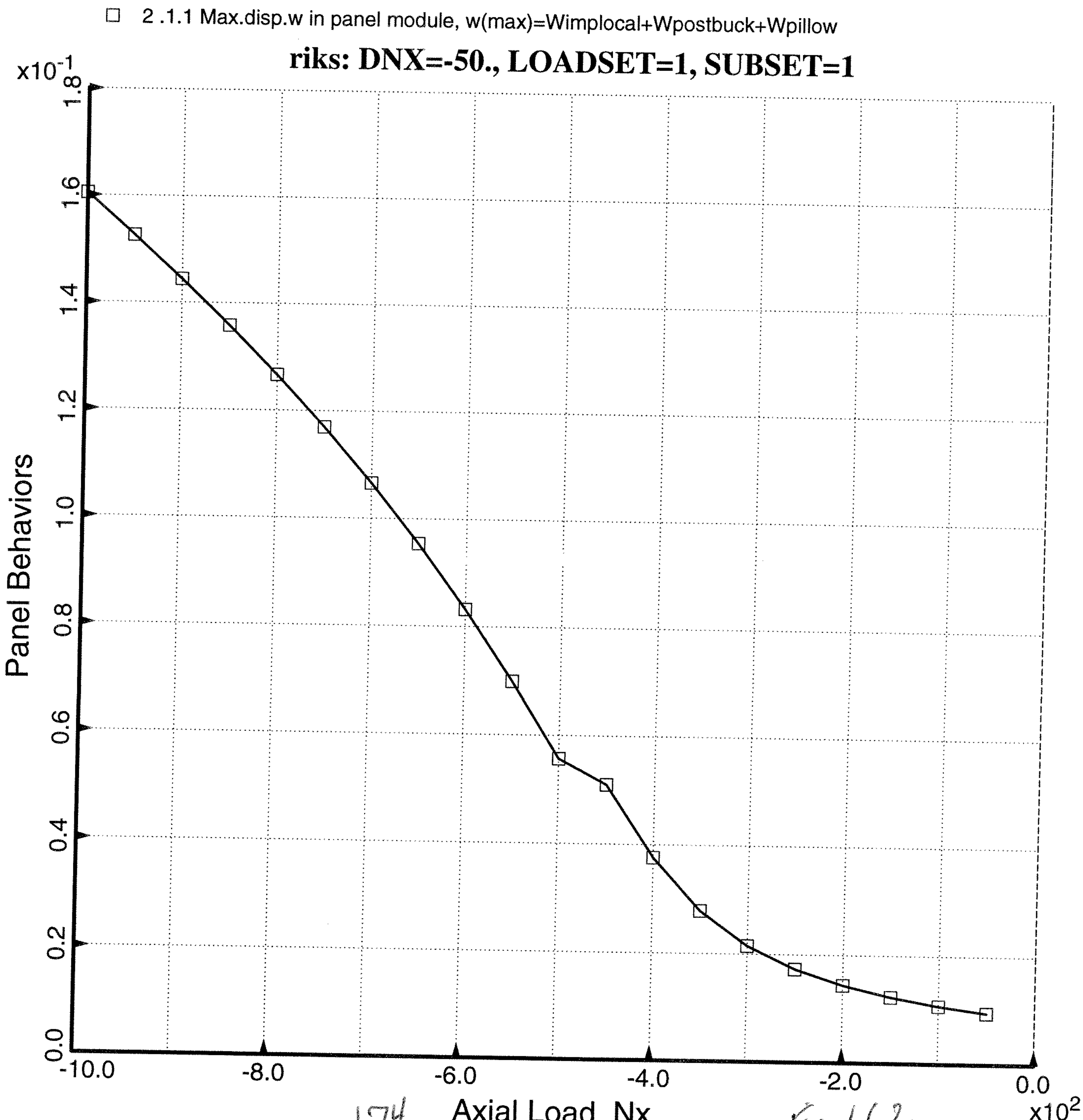


Fig. 1.61

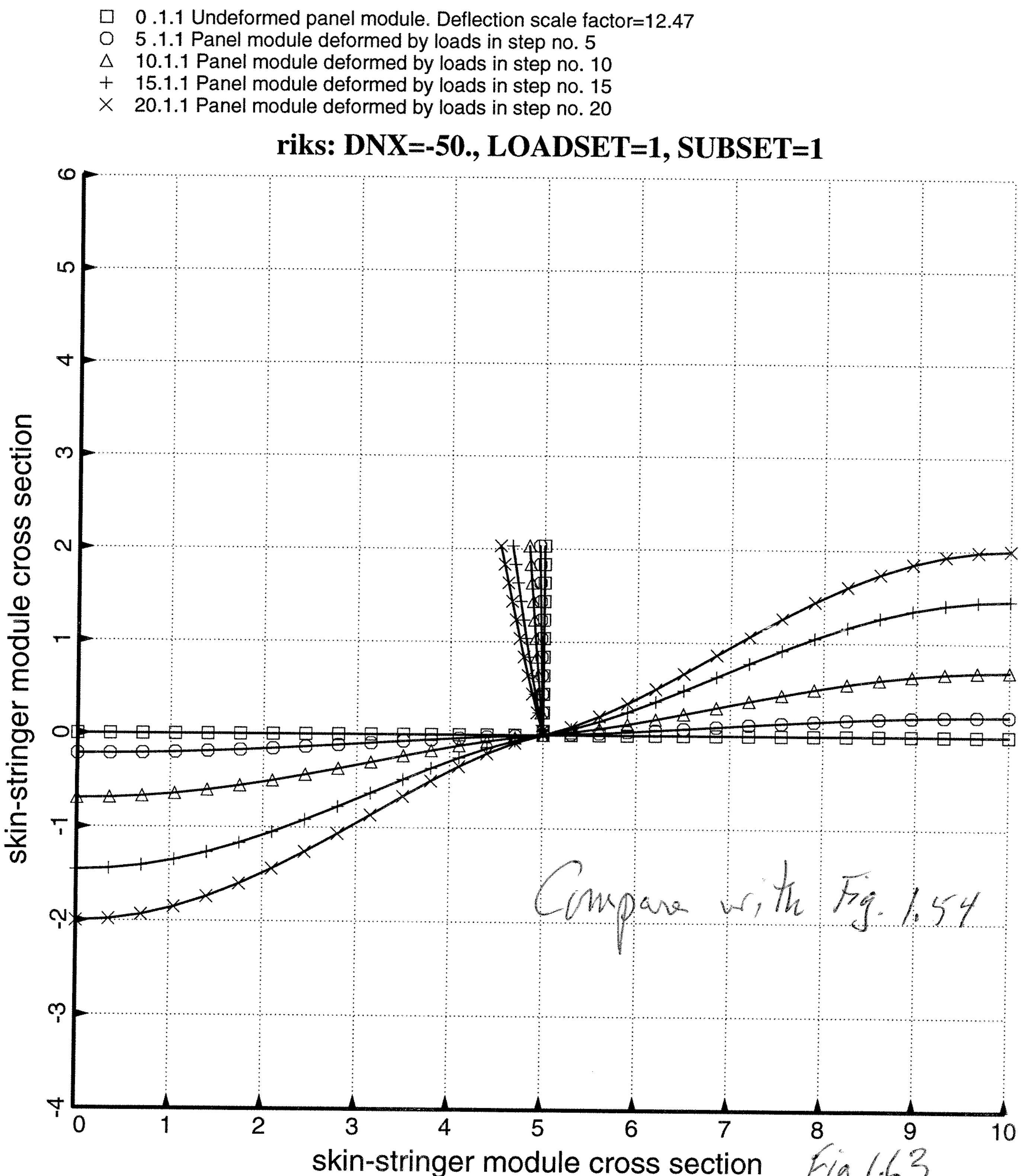
riks.4.ps (output from DIPLOT)



174

Fig. 1.62

riks.5.ps (output from DIPLOT)



Compare with Fig. 1.54

Fig. 1.63

175

riks.7.ps (output from DIPLOT)

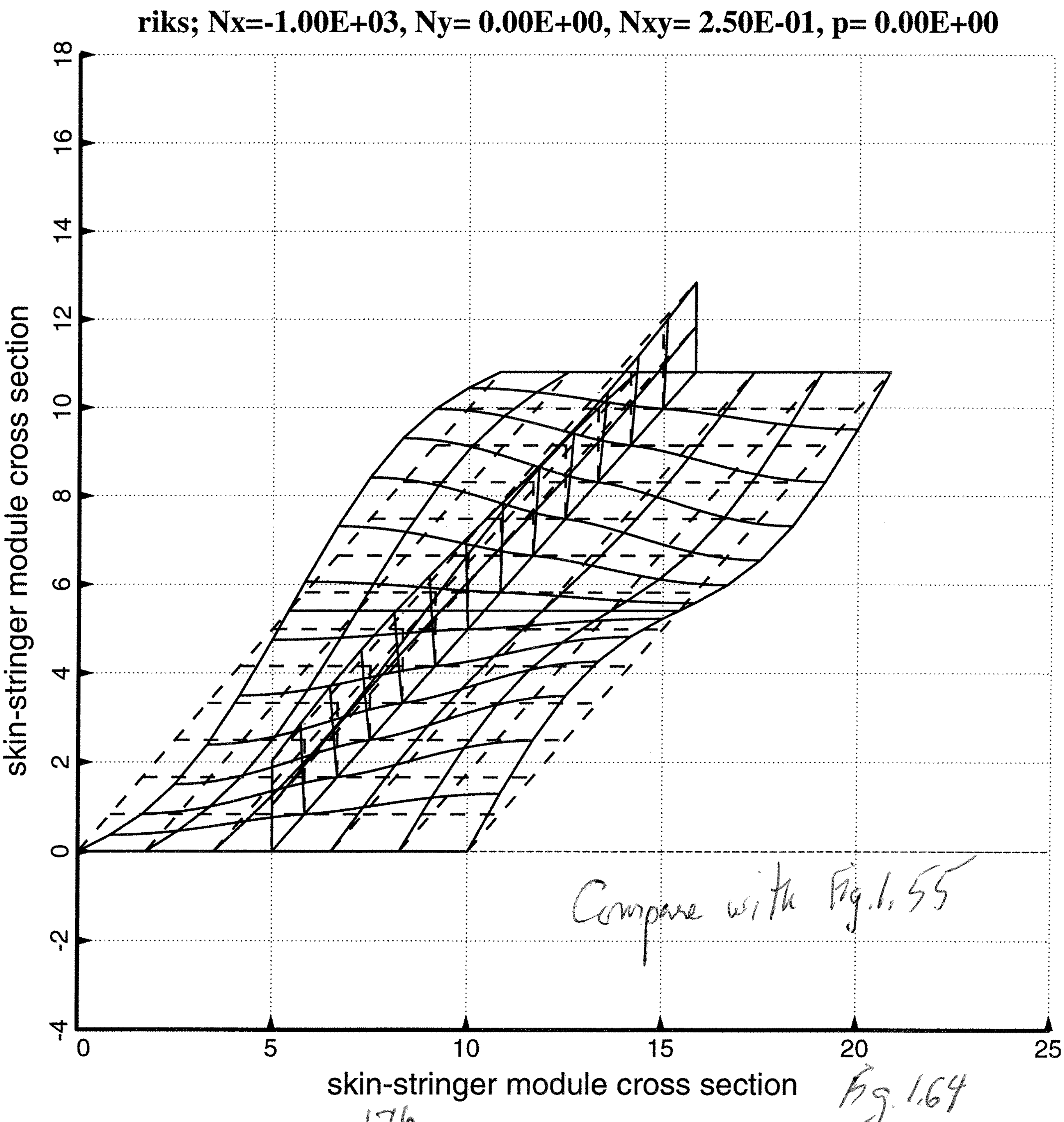


Fig. 1.64

Table 1.6) riks. STG (input for STAGSUNIT for linear buckling)

```
        n          $ Do you want a tutorial session and tutorial output?
note -> 1          $ Choose type of STAGS analysis (1,3,4,5,6),INDIC
        0          $ Restart from ISTARTth load step (0=1st nonlinear soln), ISTART
  0.5000000        $ 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
       50          $ 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
   -1000.          $ 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
        0          $ 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?
        6          $ 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)?
        n          $ 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?
        1          $ Edges normal to screen (0) in-plane deformable; (1) rigid
```

note

riks.linbuck.realstiff.rigidedges.localbuck0.5.pdf

output from STAGS processor, STAPL

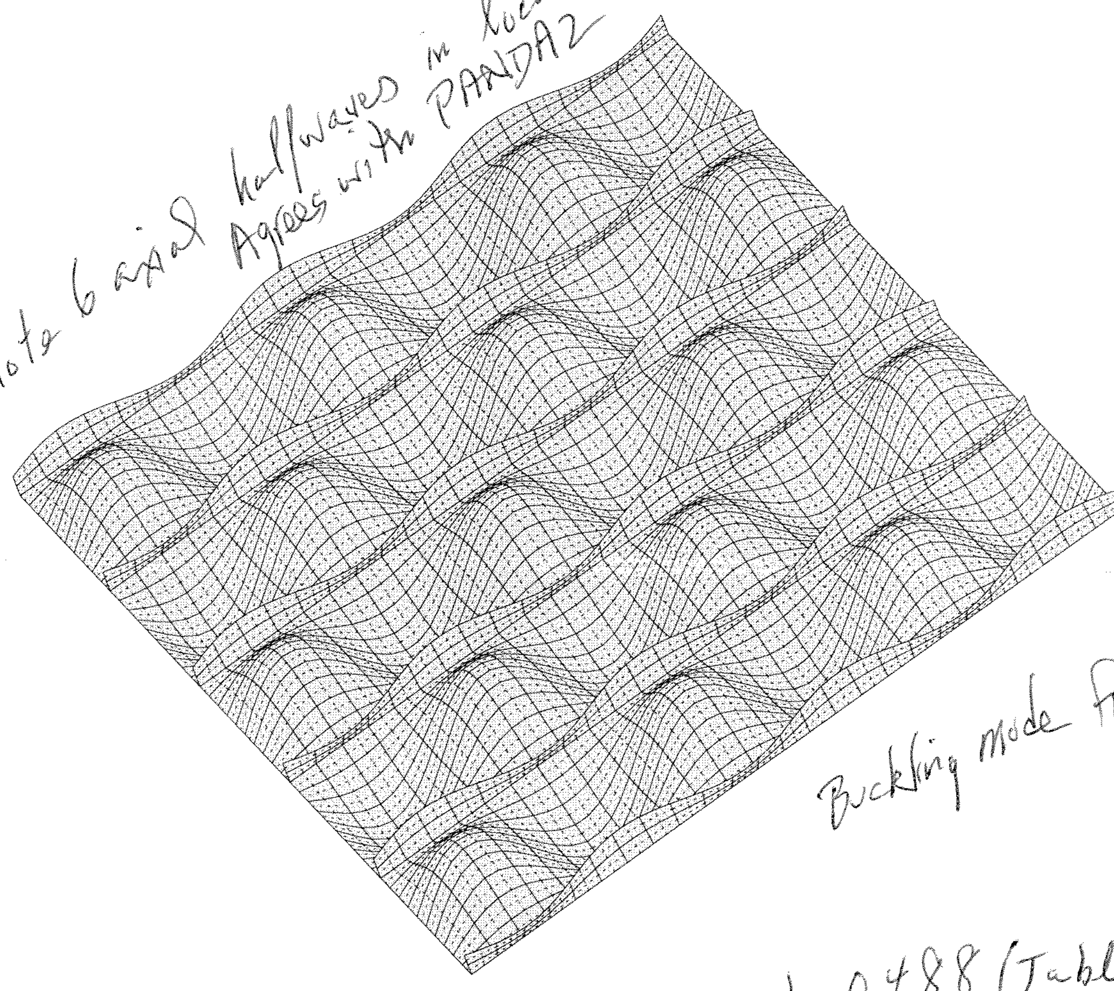


Fig. 1.65

Table 1.62 riks.STG (input for STAGSUNIT for nonlinear STAGS analysis of imperfect shell.

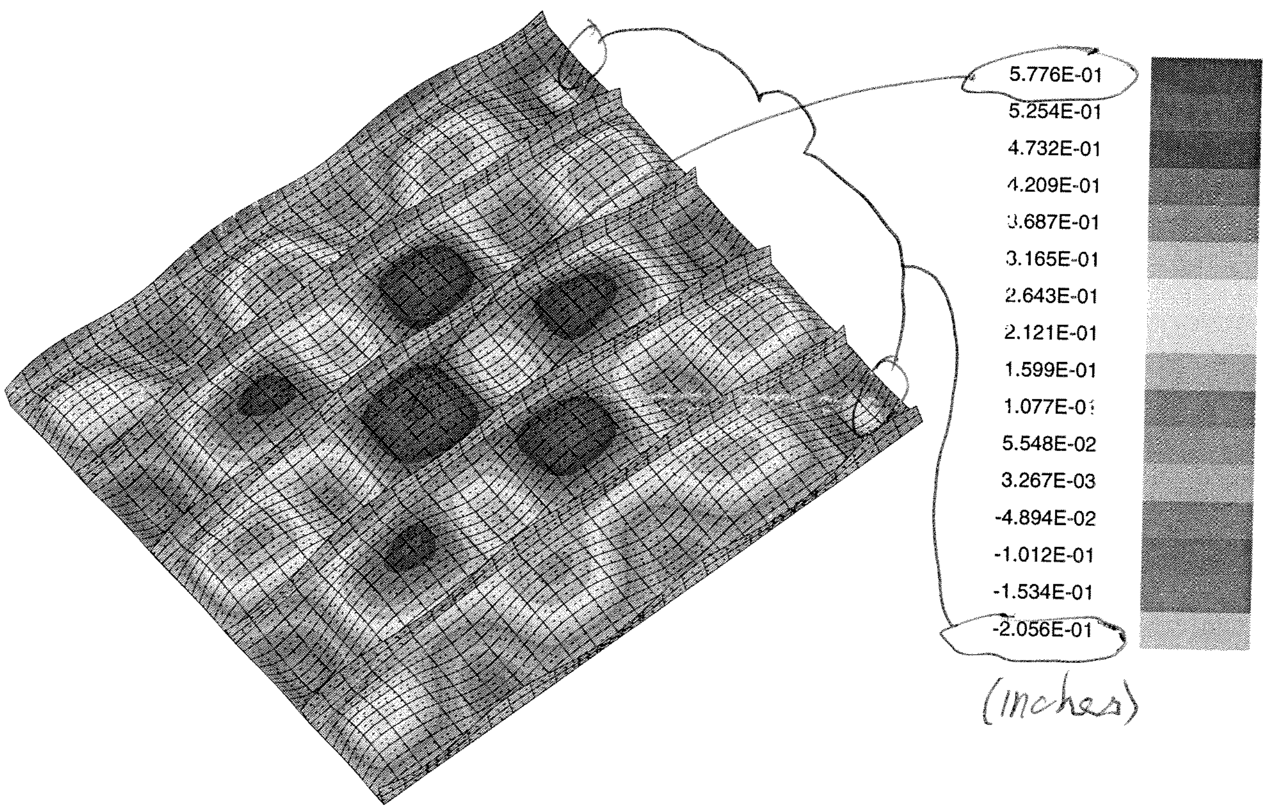
note →

```
        n          $ Do you want a tutorial session and tutorial output?
           3       $ Choose type of STAGS analysis (1,3,4,5,6),INDIC
           0       $ Restart from ISTARTth load step (0=1st nonlinear soln), ISTART
  0.5000000        $ 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
          50       $ 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
  -1000.000        $ 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
           0       $ 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
  0.5000000E-01 $ Starting load factor for Load System A, STLD(1)
  0.5000000E-01 $ Load factor increment for Load System A, STEP(1)
   1.000000        $ 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
        y          $ Have you obtained buckling modes from STAGS for this case?
        y          $ Do you want to provide initial imperfection(s)?
  0.1000000E-01 $ Amplitude of initial buckling modal imperfection, WIMPL( 1)
           1       $ Run number for which this buckling mode was computed, IRUN( 1)
           0       $ Load step number at which this buckling mode was computed, ISTEP( 1)
           1       $ Mode number at the load step ISTEP of the run IRUN: IMODE( 1)
        n          $ Do you want to provide another imperfection?
           6       $ 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)?
        n          $ 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?
           1       $ Edges normal to screen (0) in-plane deformable; (1) rigid
```

note

riks.postbuck.realstiff.sbay.rigidedges.localbuck0.5.pdf

output from STAGS processor, STAPL



solution scale = 0.7389E+01
PA= 1.00000E+00 PB= 0.00000E+00 PX= 0.00000E+00
step 17 displacement w contours
nonlinear w same view as linear buckling mode
Minimum value = -2.05574E-01, Maximum value = 5.77579E-01

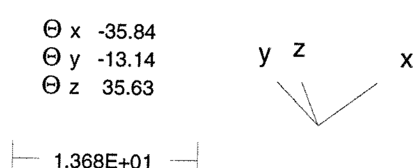
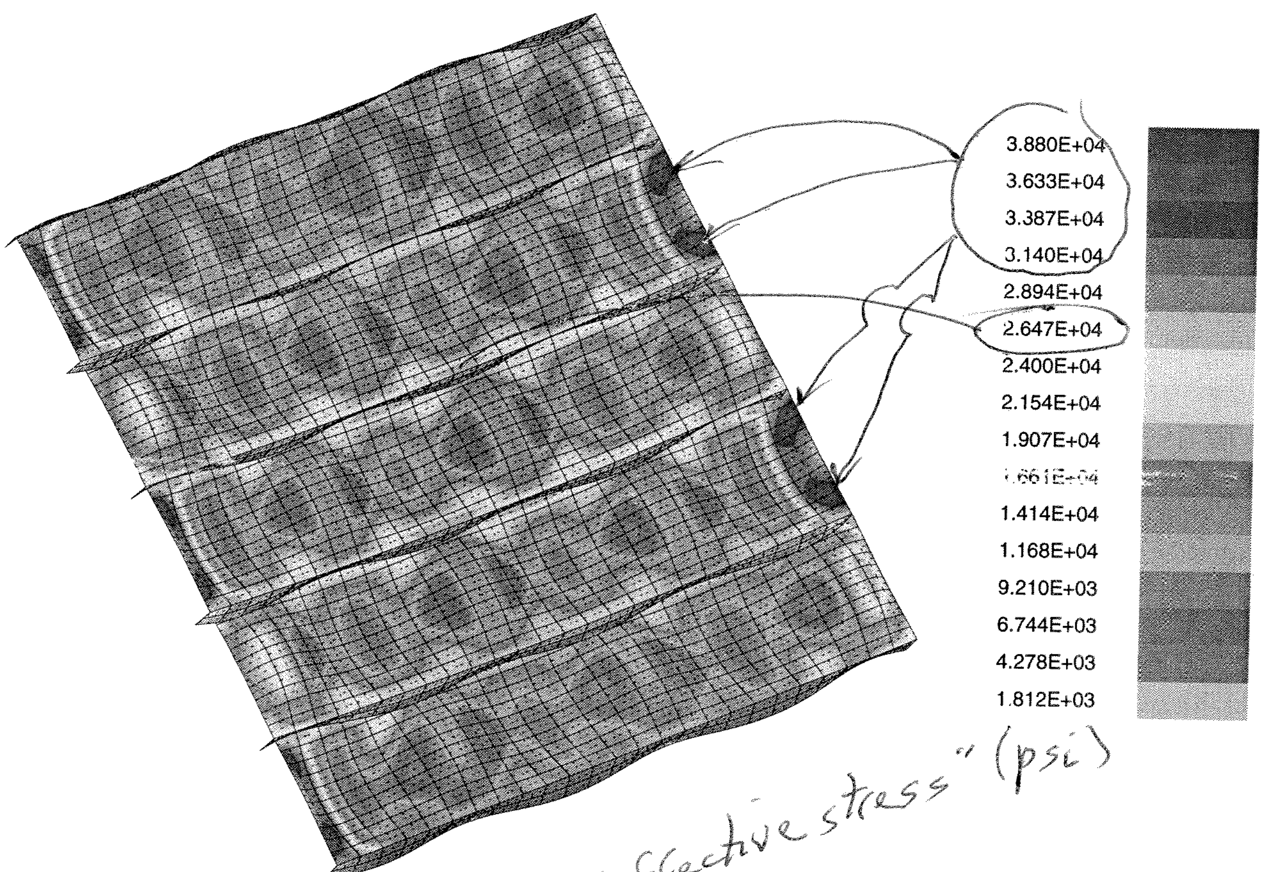


Fig. 1.66

riks.postbuck.realstiff.5bay.step17.rigidedges.localbuck0.5.seffinnerfiber.pdf

output from STAPL



seff = "effective stress" (psi)

solution scale = 0.6373E+01

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

step 17 fabrication system ,seff, layer 1, inner fiber

nonlinear effective stress - inner fiber

Minimum value = 1.81220E+03, Maximum value = 3.87991E+04

Θ x 24.00
Θ y -22.00
Θ z 30.00

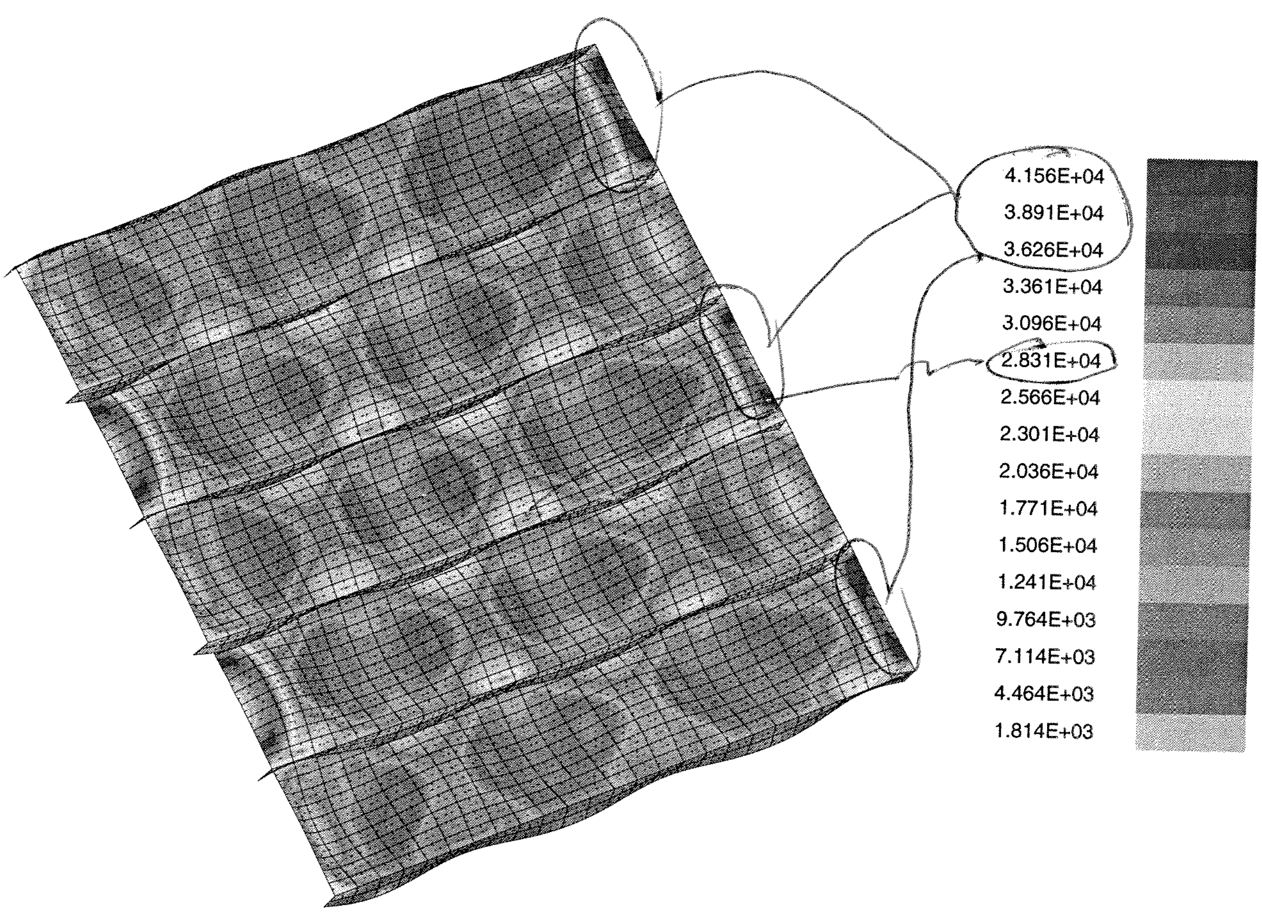
1.282E+01

y x z

Fig. 1.67

riks.postbuck.realstiff.5bay.step17.rigidedges.localbuck0.5.seffouterfiber.pdf

output from STAPL



solution scale = 0.6373E+01
PA= 1.00000E+00 PB= 0.00000E+00 PX= 0.00000E+00
step 17 fabrication system ,seff, layer 1, outer fiber
nonlinear effective stress - ~~inner fiber~~ outer
Minimum value = 1.81424E+03, Maximum value = 4.15631E+04

Θ x 24.00
Θ y -22.00
Θ z 30.00

1.282E+01

y x z

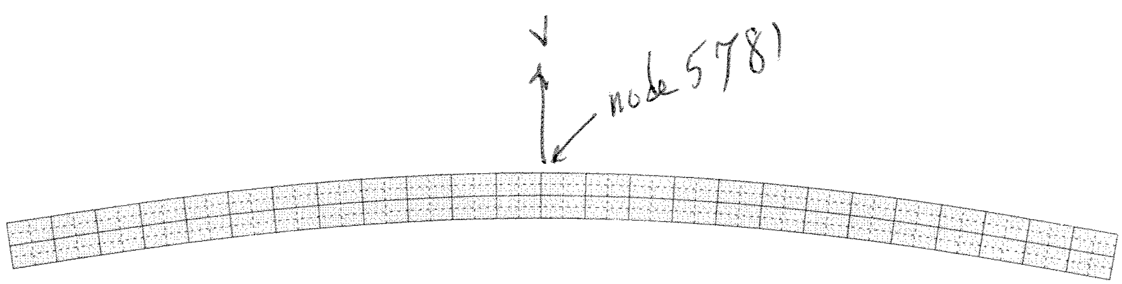
182

Fig. 1.68

riks.postbuck.realstiff.5bay.sideview.stiffxno3.localbuck0.5.pdf

output from STAGS
(Shell unit #4 = stiffener No. 3)

PANDA2 does not predict this
bowing deformation.



solution scale = 0.6283E+01
PA= 1.00000E+00 PB= 0.00000E+00 PX= 0.00000E+00
step 17 displacement deformed geometry
Nonlinear deformation, side view

Θ x -90.00
Θ y 0.00
Θ z -0.00

8.333E+00

z
x
y

Fig. 1.69

riks.stiffno3.v.compare.{input, ps}

□ Results for optimum design in which local buckling factor of safety is 0.2
○ Results for optimum design in which local buckling factor of safety is 0.5

STAGS model of "riks": max. v displacement vs. axial load, Nx

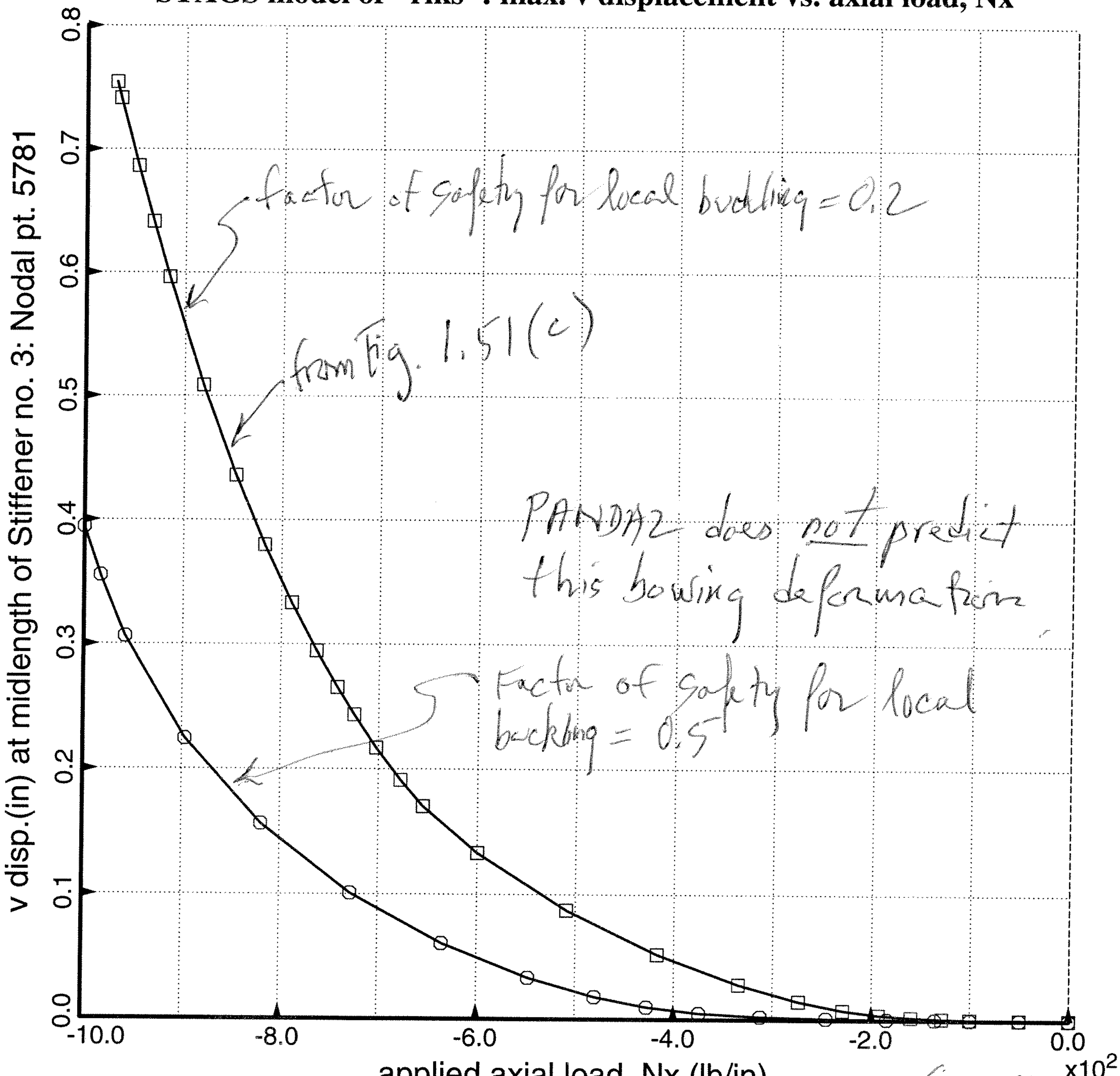


Fig. 1.70

Table 1.63 riks.PAN (input for PANEL)

```
     n          $ Do you want a tutorial session and tutorial output?
50.00000        $ Panel length in the plane of the screen, L2
      1         $ Enter control (0 or 1) for stringers at panel edges
      1         $ Enter ILOCAL=0 for panel buckling; 1 for local buckling, ILOCAL
      6         $ Number of halfwaves in the axial direction [see H(elp)],NWAVE
      3         $ How many eigenvalues (get at least 3) do you want?
```

obtained from Margin No. 1 in Table 1.57 (M=6)

output from BIGBOSOR4
(bosorplot)

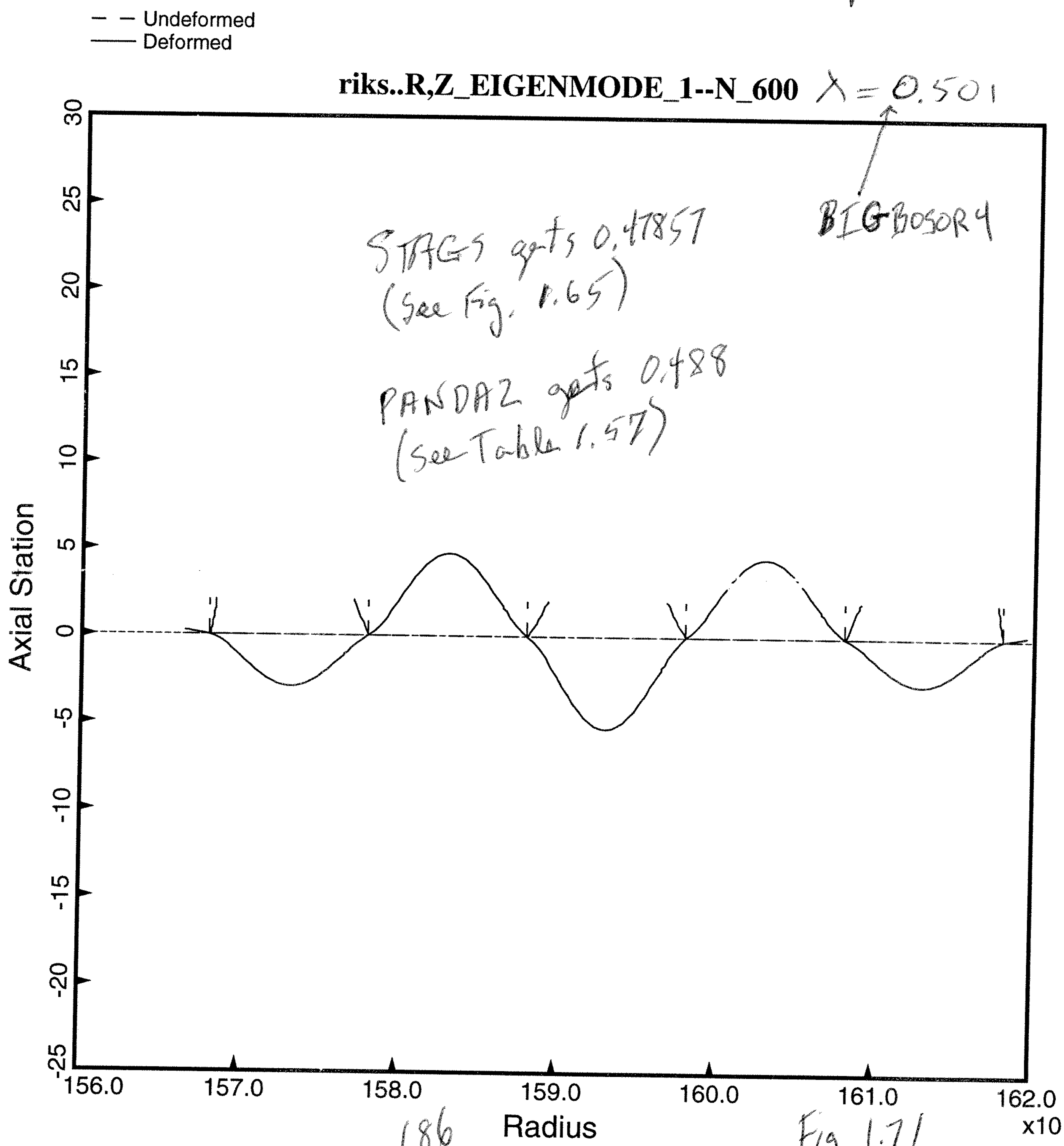


Fig. 1.71

Sub-section 1.4

Curved (Cylindrical)

Stiffened Panel

50 × 50 (arc) inches

$N_x = -1000$ lb/in

Table 1.64

Begin Sub-section 1.4

rikscurved.runstream

7 July, 2008

This runstream is for the optimization, analysis, and verification of a CURVED panel with axially oriented rectangular stiffeners (stringers). the desision variables are: stringer spacing, skin thickness, stringer thickness, and stringer height.

Several things are done:

1. The panel is first optimized by PANDA2 (analysis type ITYPE = 1).

2. Results are then obtained by PANDA2 running in the "fixed design analysis branch (analysis type ITYPE = 2).

3. A BIGBOSOR4 model of local buckling is then derived via the PANDA2 processor called PANEL.

4. Linear bifurcation buckling and nonlinear equilibrium STAGS runs are then executed. Input files, *.bin and *.inp, for STAGS are generated via the PANDA2 processor called STAGSUNIT.

5. The PANDA2 processor called CHANGE is used to save the optimized design previously obtained by PANDA2 in Item 1, and PANDA2 is then run in a "test simulation" mode, that is, analysis type ITYPE = 3.

6. Linear bifurcation buckling and nonlinear equilibrium STAGS runs are again executed, this time with a different boundary condition used along the two straight edges of the curved panel.

7. Nonlinear equlibrium STAGS run with same boundary conditions as in Item 6, except that the rotation about a circumferentially oriented tangent to the curved edges is held at zero during the nonlinear analysis. That is, the STAGS variable called "rv" = 0 along the two curved edges during the nonlinear STAGS run.

The case is called "rikscurved".

```
panda2log
begin           (input = rikscurved.BEG = Table 1.65)
setup
decide          (input = rikscurved.DEC = Table 1.66)
mainsetup       (input = rikscurved.OPT, ITYPE=1, Table 1.67)
pandaopt        (optimize)
pandaopt        (optimize)
pandaopt        (optimize) (Or you can use SUPEROPT, probably coming up
pandaopt        (optimize)  with a slightly lighter optimum design that
pandaopt        (optimize)  could be quite different from the optimum
pandaopt        (optimize)  design obtained via the 8 sequential executions
pandaopt        (optimize)  of PANDAOPT listed here.)
pandaopt        (optimize)
(Inspect the rikscurved.OPP file = Table 1.68)
chooseplot      (cp rikscurved.itype1.cpl rikscurved.CPL; input = rikscurved.CPL = Table 1.69)
diplot          (obtain postscript files for plotting: rikscurved.3.ps, rikscurved.5.ps;
                 see Figs. 1.72 and 1.73)
mainsetup       (keep NPRINT = 0 and change ITYPE to 2, analysis of fixed design;
                 see the top of p. 1 of Table 1.70)
pandaopt        (analyze the fixed design, which is the optimum design. Table 1.70)


(Next, generate input data valid for BIGBOSOR4 for checking local buckling)

panel           (set up input file, rikscurved.ALL, for BIGBOSOR4 procssor
                 called BIGBOSORALL. The input file for PANEL is called rikscurved.PAN ;
                 Table 1.71. The output file from PANEL is called rikscurved.ALL .)

(go to directory where you want to run BIGBOSOR4. Copy rikscurved.ALL there. )
bigbosor4log    (activate the BIGBOSOR4 commands)
bigbosorall     (run BIGBOSOR4. Search the rikscurved.OUT file for the string,
                 "EIGENVALUE("  )
cleanup         (clean up the BIGBOSOR4 files. A suitable new rikscurved.ALL file
                 will be produced, one that can be edited to reset the range of
                 circumferential wavenumbers, N0B, NMINB, NMAXB, INCRB, over which
                 to perform linear buckling. See the top of Table 1.72 .)

(edit the now cleaned up rikscurved.ALL file. Search for the string, N0B (NzeroB),
```

```
                 and reset N0B, NMINB, NMAXB, INCRB to values that will capture
                 the critical (lowest) buckling eigenvalue. See the bottom of Table 1.72 .)
bigbosorall     (run BIGBOSOR4 and inspect the rikscurved.OUT file by again searching
                 for the string, "EIGENVALUE(" . See Table 1.73 )
bosorplot       (get plot of the undeformed cross section of the panel and
                 the critical (lowest eigenvalue) buckling mode; Figs. 1.74 and 1.75)
cleanup


(Next, set up input data for STAGS linear and nonlinear runs,
 this first time with "in-plane deformable" straight edges.)

stagsunit       (input = rikscurved.STG = Table 1.74)

(stagsunit is a PANDA2 processor that generates the two input files
 required for the execution of STAGS: rikscurved.bin and rikscurved.inp )

(Run STAGS, first in linear (INDIC = 1) mode, then in nonlinear (INDIC = 3)
 mode. Edit the rikscurved.inp file from the linear run by adding one
 buckling modal imperfection with amplitude 0.01 inch. Produce the proper
 rikscurved.bin file for nonlinear analysis. See Fig. 1.76 for results
 from STAGS from linear bifurcation buckling analysis (INDIC=1; Fig. 1.76)
 and from the nonlinear equilibrium analysis of the shell with one
 buckling modal imperfection (INDIC = 3; Figs. 1.77 - 1.80).)

(The use of STAGS is described in several recent PANDA2 papers.
 Briefly, one first runs a linear buckling analysis with STAGS
 in order to obtain a buckling modal imperfection shape suitable
 for use as an initial imperfection. Then one runs a nonlinear       (See Figs. 1.76
 equilibrium analysis of the shell or panel with its buckling                - 1.80)
 modal imperfection shape with user-specified amplitude in
 order to find the load-bearing capability of the imperfect structure..
 No further description of how to do this will be given here.
 See the recent PANDA2 papers for more details.)


(Next, go back to the directory where you are running PANDA2 and
 1. use CHANGE to save the optimized design, and
 2. set up an execution of MAINSETUP and PANDAOPT for analysis type,
 ITYPE = 3: test simulation of the optimized panel)

change          (Use change to save the optimum design generated above.
                 Input for CHANGE is saved in the file, rikscurved.CHG = Table 1.75)
setup           (PANDA2 sets up matrix templates)
mainsetup       (choose loading, etc. input = rikscurved.OPT for ITYPE=2;
                 see the top of p. 1 of Table 1.70)
pandaopt        (run PANDAOPT for fixed design (ITYPE=2) and check against the
                 results from the previous ITYPE=2 run for the same optimized
                 design to make certain that the rikscurved.CHG file is correct.
                 Compare the rikscurved.OPM file with results listed in Table 1.70 .)


(Next, run analysis type ITYPE = 3 (test simulation) for the optimum design)

mainsetup       (choose loading, strategy, analysis type, etc. using ITYPE=3;
                 see Table 1.76 .)
pandaopt        (PANDA2 performs ITYPE=3 analysis. Input=flat.OPT)
chooseplot      (choose what to plot: input = rikscurved.CPL = Table 1.77)
diplot          (PANDA2 gets postscript plot files, rikscurved.3.ps,
                 rikscurved.4.ps, rikscurved.5.ps, rikscurved.7.ps;
                 see Figs. 1.81, 1.82, 1.83, 1.84, respectively.)


(Next, set up input data for new STAGS linear and nonlinear runs,
 this time with "in-plane rigid" straight edges.)

stagsunit       (input = rikscurved.STG = Table 1.78)

(stagsunit is a PANDA2 processor that generates the two input files
 required for the execution of STAGS: rikscurved.bin and rikscurved.inp )

(Run STAGS, first in linear (INDIC = 1) mode, then in nonlinear (INDIC = 3)
 mode. Edit the rikscurved.inp file from the linear run by adding one
 buckling modal imperfection with amplitude 0.01 inch. Produce the proper
 rikscurved.bin file for nonlinear analysis. See Figs. 1.85 - 1.90 for results
 from STAGS from linear bifurcation buckling analysis (INDIC=1; Figs. 1.85 - 1.87)
 and from the nonlinear equilibrium analysis of the shell with one
 buckling modal imperfection (INDIC = 3; Figs. 1.88 - 1.90).)
```

```
(Next, set up input data for a new STAGS nonlinear run, this time
 with the STAGS rotation component, "rv" = 0 in the panel skin along
 the two curved ends of the stiffened panel.)

stagsunit       (input = rikscurved.STG = Table 1.79)

(Run STAGS in the nonlinear mode (INDIC = 3). See Figs. 1.91 - 1.94 .)

(Edit rikscurved.inp to reset the buckling modal imperfection amplitude
 equal to 0.000001 and restart the nonlinear STAGS run from the beginning.
 See Fig. 1.95).


(Next, start from scratch and re-optimize with PANDA2, this time using
the PANDA2 processor called SUPEROPT to get a "global" optimum design)

panda2log
begin           (input = rikscurved.BEG = Table 1.65)
setup
decide          (input = rikscurved.DEC = Table 1.66)
mainsetup       (input = rikscurved.OPT, ITYPE=1, Table 1.67)
superopt        (Use 6 PANDAOPTs per AUTOCHANGE. Obtain "global" optimum)
chooseplot      (input = rikscurved.CPL = Table 1.55(b), for example)
diplot          (obtain and plot the rikscurved.5.ps file. See Fig. 1.96)
mainsetup       (change analysis type from ITYPE = 1 to ITYPE = 2)
pandaopt        (obtain results for the "globally" optimized design, Table 1.80)
```

Table 1.65 rikscurved.BEG (input for BEGIN)

```
       n        $ Do you want a tutorial session and tutorial output?
      50        $ Panel length normal to the plane of the screen, L1
      50        $ Panel length in the plane of the screen, L2
       r        $ Identify type of stiffener along L1 (N,T,J,Z,R,A,C,G)
      10        $ stiffener spacing, b
       3        $ width of stringer base, b2 (must be > 0, see Help)
  2.000000      $ height of stiffener (type H for sketch), h
       n        $ Are the stringers cocured with the skin?
  1000000.      $ What force/(axial length) will cause web peel-off?
       n        $ Is the next group of layers to be a "default group" (12 layers!)?
       1        $ number of layers in the next group in Segment no.( 1)
       n        $ Can winding (layup) angles ever be decision variables?
       1        $ layer index (1,2,...), for layer no.( 1)
       y        $ Is this a new layer type?
 0.8704101E-01  $ thickness for layer index no.( 1)
       0        $ winding angle (deg.) for layer index no.( 1)
       1        $ material index (1,2,...) for layer index no.( 1)
       n        $ Any more layers or groups of layers in Segment no.( 1)
       n        $ Is the next group of layers to be a "default group" (12 layers!)?
       1        $ number of layers in the next group in Segment no.( 2)
       n        $ Can winding (layup) angles ever be decision variables?
       1        $ layer index (1,2,...), for layer no.( 1)
       n        $ Is this a new layer type?
       n        $ Any more layers or groups of layers in Segment no.( 2)
       n        $ Is the next group of layers to be a "default group" (12 layers!)?
       1        $ number of layers in the next group in Segment no.( 3)
       n        $ Can winding (layup) angles ever be decision variables?
       2        $ layer index (1,2,...), for layer no.( 1)
       y        $ Is this a new layer type?
 0.1000000      $ thickness for layer index no.( 2)
       0        $ winding angle (deg.) for layer index no.( 2)
       2        $ material index (1,2,...) for layer index no.( 2)
       n        $ Any more layers or groups of layers in Segment no.( 3)
       0        $ choose external (0) or internal (1) stringers
       n        $ Identify type of stiffener along L2  (N, T, J, Z, R, A)
       y        $ Is the panel curved in the plane of the screen (Y for cyls.)?
  50.00000      $ Radius of curvature (cyl. rad.) in the plane of screen, R
       n        $ Is panel curved normal to plane of screen? (answer N)
       y        $ Is this material isotropic (Y or N)?
 0.1000000E+08  $ Young's modulus,                    E( 1)
 0.3000000      $ Poisson's ratio,                   NU( 1)
 3846000.       $ transverse shear modulus,         G13( 1)
       0        $ Thermal expansion coeff.,       ALPHA( 1)
       0        $ residual stress temperature (positive),TEMPTUR( 1)
       n        $ Want to supply a stress-strain "curve" for this mat'l? (N)
       y        $ Want to specify  maximum effective stress ?
  1000000.      $ Maximum allowable effective stress in material type( 1)
       n        $ Do you want to take advantage of "bending overshoot"?
 0.1000000      $ weight density (greater than 0!) of material type( 1)
       n        $ Is lamina cracking permitted along fibers (type H(elp))?
       y        $ Is this material isotropic (Y or N)?
 0.1000000E+08  $ Young's modulus,                    E( 2)
 0.3000000      $ Poisson's ratio,                   NU( 2)
 3846000.       $ transverse shear modulus,         G13( 2)
       0        $ Thermal expansion coeff.,       ALPHA( 2)
       0        $ residual stress temperature (positive),TEMPTUR( 2)
       n        $ Want to supply a stress-strain "curve" for this mat'l? (N)
       y        $ Want to specify  maximum effective stress ?
  60000.00      $ Maximum allowable effective stress in material type( 2)
       n        $ Do you want to take advantage of "bending overshoot"?
 0.1000000      $ weight density (greater than 0!) of material type( 2)
       n        $ Is lamina cracking permitted along fibers (type H(elp))?
       2        $ Prebuckling: choose 0=bending included; 2=use membrane theory
       0        $ Buckling: choose 0=simple support or 1=clamping
```

Error! This should have been 60000!

Table 1.66 rikscurved.DEC (input for DECIDE)

```
    n          $ Do you want a tutorial session and tutorial output?
    n          $ Want to use default for thickness decision variables (type H(elp)?
      1        $ Choose a decision variable (1,2,3,...)
 3.000000      $ Lower bound of variable no.( 1)
 10.00000      $ Upper bound of variable no.( 1)
    y          $ Any more decision variables (Y or N) ?
      3        $ Choose a decision variable (1,2,3,...)
0.2000000      $ Lower bound of variable no.( 3)
 10.00000      $ Upper bound of variable no.( 3)
    y          $ Any more decision variables (Y or N) ?
      4        $ Choose a decision variable (1,2,3,...)
0.1000000E-01 $ Lower bound of variable no.( 4)
 1.000000      $ Upper bound of variable no.( 4)
    y          $ Any more decision variables (Y or N) ?
      5        $ Choose a decision variable (1,2,3,...)
0.1000000E-01 $ Lower bound of variable no.( 5)
 1.000000      $ Upper bound of variable no.( 5)
    n          $ Any more decision variables (Y or N) ?
    y          $ Any linked variables (Y or N) ?
      2        $ Choose a linked variable (1,2,3,...)
      1        $ To which variable is this variable linked?
0.3333000      $ Assign a value to the linking coefficient, C(j)
    n          $ Any other decision variables in the linking expression?
    n          $ Any constant C0 in the linking expression (Y or N)?
    n          $ Any more linked variables (Y or N) ?
    n          $ Any inequality relations among variables? (type H)
    y          $ Any escape variables (Y or N) ?
    y          $ Want to have escape variables chosen by default?
```

Table 1.67 rikscurved.OPT for optimization

```
      n         $ Do you want a tutorial session and tutorial output?
  -1000.        $ 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)
        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?
 1.0000000      $ 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)
  0.000000      $ 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)
        1       $ 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 -->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)
```

input for MAINSETUP & PANDAOPT

p. 1 of 5 (Table 1.68) rikscurved.OPP (output from optimization) 5 pages

Table 1.68

```
************ July 2007 VERSION OF PANDA2   ************
***************** THIS IS THE  rikscurved.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 rikscurved.  Later, when
the final design has been obtained, the entire history of the
design evolution for the specific case rikscurved can be plotted.
*********************************************************

 ITRTOT,NITER,ITRPLT,ITRLST = 33 1 33 32
 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  33 ITERATIONS ******

  1          B(STR):stiffener spacing, b: STR seg=NA, layer=NA =
 1.0000E+01  9.0000E+00  8.2800E+00  7.7501E+00  7.3533E+00  7.0521E+00  7.0521E+00  7.3490E+00»
 6.8771E+00  6.4370E+00
 6.1074E+00  5.8573E+00  5.8573E+00  6.4430E+00  5.9275E+00  5.5482E+00  5.2641E+00  5.0485E+00»
 5.0485E+00  4.6471E+00
 4.2753E+00  4.0017E+00  3.7968E+00  3.6413E+00  3.6413E+00  3.9629E+00  3.6458E+00  3.4125E+00»
 3.5872E+00  3.5872E+00
 3.6236E+00  3.6236E+00  3.6236E+00

  2         B2(STR):width of stringer base, b2 (must be > 0, see Help): STR seg=2 , lay =
 3.3330E+00  2.9997E+00  2.7597E+00  2.5831E+00  2.4508E+00  2.3505E+00  2.3505E+00  2.4494E+00»
 2.2921E+00  2.1454E+00
 2.0356E+00  1.9522E+00  1.9522E+00  2.1474E+00  1.9757E+00  1.8492E+00  1.7545E+00  1.6827E+00»
 1.6827E+00  1.5489E+00
 1.4250E+00  1.3338E+00  1.2655E+00  1.2136E+00  1.2136E+00  1.3208E+00  1.2152E+00  1.1374E+00»
 1.1956E+00  1.1956E+00
 1.2077E+00  1.2077E+00  1.2077E+00

  3          H(STR):height of stiffener (type H for sketch), h: STR seg=3 , layer=NA =
 2.0000E+00  1.8000E+00  1.6560E+00  1.5500E+00  1.4707E+00  1.4104E+00  1.4104E+00  1.4521E+00»
 1.4208E+00  1.3299E+00
 1.3111E+00  1.2808E+00  1.2808E+00  1.3662E+00  1.3498E+00  1.3422E+00  1.3516E+00  1.3523E+00»
 1.3523E+00  1.3694E+00
 1.3634E+00  1.3558E+00  1.3496E+00  1.3423E+00  1.3423E+00  1.3897E+00  1.3807E+00  1.3699E+00»
 1.3837E+00  1.3837E+00
 1.3916E+00  1.3916E+00  1.3916E+00

  4      T(1 )(SKN):thickness for layer index no.(1 ): SKN seg=1 , layer=1 =
 8.7041E-02  7.9855E-02  7.3467E-02  6.8765E-02  6.9250E-02  6.6413E-02  6.6413E-02  5.9772E-02»
 5.4990E-02  5.5992E-02
 5.5301E-02  5.3058E-02  5.3058E-02  4.7752E-02  4.5944E-02  4.4038E-02  4.2529E-02  4.1365E-02»
 4.1365E-02  3.7228E-02
 3.5191E-02  3.3789E-02  3.2812E-02  3.2020E-02  3.2020E-02  2.8818E-02  2.7499E-02  2.6172E-02»
 2.7142E-02  2.7142E-02
 2.6596E-02  2.6596E-02  2.6596E-02

  5      T(2 )(STR):thickness for layer index no.(2 ): STR seg=3 , layer=1 =
 1.0000E-01  1.1000E-01  1.1562E-01  1.1485E-01  1.2073E-01  1.1694E-01  1.1694E-01  1.0712E-01»
 1.1569E-01  1.1747E-01
 1.1442E-01  1.1911E-01  1.1911E-01  1.2182E-01  1.1917E-01  1.1618E-01  1.1370E-01  1.1212E-01»
 1.1212E-01  1.0903E-01
 1.0494E-01  1.0171E-01  9.9186E-02  9.7863E-02  9.7863E-02  1.0363E-01  1.0058E-01  9.8189E-02»
 9.9963E-02  9.9963E-02
 1.0074E-01  1.0074E-01  1.0074E-01

********** OBJECTIVE FOR  33 ITERATIONS *********

  1     WEIGHT OF THE ENTIRE PANEL =
 2.6760E+01  2.5464E+01  2.4148E+01  2.2934E+01  2.3349E+01  2.2451E+01  2.2451E+01  2.0234E+01»
 1.9723E+01  2.0065E+01
 1.9966E+01  1.9776E+01  1.9776E+01  1.8396E+01  1.8270E+01  1.8036E+01  1.7930E+01  1.7849E+01»
 1.7849E+01  1.7339E+01
 1.7164E+01  1.7062E+01  1.7017E+01  1.7024E+01  1.7024E+01  1.6290E+01  1.6398E+01  1.6397E+01»
 1.6425E+01  1.6425E+01
 1.6320E+01  1.6320E+01  1.6320E+01

  1     Absolute values of maximum constraint gradients, GRDPLT =
 4.1925E+00  4.2092E+00  4.5214E+00  4.1582E+00  4.6494E+00  0.0000E+00  6.8388E+00  4.9949E+00»
 3.9219E+00  4.8745E+00
 4.7983E+00  0.0000E+00  4.5270E+00  4.6477E+00  4.6578E+00  4.6376E+00  4.5856E+00  0.0000E+00»
```

```
 4.5104E+00  4.3343E+00
 4.9824E+00  4.8939E+00  4.7044E+00  0.0000E+00  4.8073E+00  4.7748E+00  4.7898E+00  4.8333E+00»
 4.7366E+00  4.7366E+00
 4.7501E+00  4.7501E+00  4.7501E+00

****** DESIGN MARGINS FOR  33 ITERATIONS ******
****** LOAD SET NO. 1                   ******
****** SUB-CASE (1=MIDLENGTH, 2=PANEL END)= 1 *****

  1   Local buckling: discrete model =
 6.5272E-01  7.7727E-01  8.2071E-01  7.8477E-01  1.1020E+00  1.0305E+00  1.0305E+00  3.7854E-01»
 4.2170E-01  7.0926E-01
 8.3777E-01  8.9139E-01  8.9138E-01  2.2918E-01  3.4681E-01  4.0516E-01  4.5701E-01  4.9810E-01»
 4.9810E-01  4.2105E-01
 4.8843E-01  5.6162E-01  6.3482E-01  6.9631E-01  6.9631E-01  1.2854E-01  2.2468E-01  2.6969E-01»
 2.3551E-01  2.3551E-01
 1.5736E-01  1.5736E-01  1.5736E-01

  2   Local buckling: Koiter theory. =
 6.5412E-01  7.7740E-01  8.1991E-01  7.7921E-01  1.0955E+00  1.0218E+00  1.0218E+00  3.7267E-01»
 4.0836E-01  6.9336E-01
 8.2134E-01  8.6984E-01  8.6984E-01  2.1168E-01  3.2679E-01  3.8363E-01  4.3428E-01  4.8409E-01»
 4.8409E-01  3.9482E-01
 4.6113E-01  5.3376E-01  6.0388E-01  6.6561E-01  6.6561E-01  1.0589E-01  2.0027E-01  2.4347E-01»
 2.1033E-01  2.1033E-01
 1.3380E-01  1.3380E-01  1.3380E-01

  3   Hi-axial-wave post-post-buckling of module =
-4.2656E-02 -1.3749E-02 -2.9226E-02 -6.4102E-02 -1.0831E-02 -4.0253E-02  2.7326E-01 -4.7413E-02»
-8.9736E-02 -2.1897E-02
-6.5569E-03 -1.6620E-02  2.7584E-01 -3.4426E-02 -4.5114E-03 -6.8438E-03 -5.3400E-03 -4.9529E-03»
 8.5879E-02 -1.0204E-04
-6.9772E-03 -8.1316E-03 -6.4670E-03 -4.5585E-03  3.2120E-01 -2.2205E-02  2.5634E-03 -2.8944E-03»
 6.4114E-04  4.4191E-02
-2.3823E-04 -2.3823E-04 -2.3823E-04

  4   m=? lateral-torsional buckling =
 2.5672E-01  2.1012E-01  1.7069E-01  1.1525E-01  1.6014E-01  1.1716E-01  1.1716E-01 -5.7314E-02»
-2.3409E-02  3.2888E-02
 2.9413E-02  6.0234E-02  6.0234E-02 -2.2566E-02 -5.8743E-03 -5.1011E-03 -9.6731E-03 -2.5825E-03»
-2.5828E-03 -8.9186E-03
-1.0126E-02 -9.5981E-03 -1.1796E-02 -2.1610E-03 -2.1610E-03 -2.6598E-03  1.8526E-03  4.2510E-04»
-2.5168E-03 -2.4289E-03
-3.1653E-03 -3.1653E-03 -3.1653E-03

  5   buckling: stringer seg.3 . MIDLENGTH =
-2.2701E-01  1.1648E-01  3.5510E-01  4.2744E-01  8.6391E-01  8.0328E-01  8.0328E-01  2.1938E-01»
 4.8250E-01  8.3399E-01
 8.0850E-01  0.0000E+00  0.0000E+00  7.2346E-01  7.1547E-01  6.9812E-01  6.7053E-01  6.3699E-01»
 6.3699E-01  5.5417E-01
 5.1237E-01  4.9515E-01  4.4598E-01  4.8439E-01  4.8439E-01  4.4377E-01  4.6037E-01  4.8174E-01»
 4.4652E-01  4.4641E-01
 4.4727E-01  4.4727E-01  4.4727E-01

  6   buckling: stringer seg.3 . NO POSTBK =
 1.2230E-01  6.1539E-01  9.6632E-01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  8.4530E-01»
 0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00»
 0.0000E+00  0.0000E+00
 9.4093E-01  8.9198E-01  8.0810E-01  8.3866E-01  8.3866E-01  8.0532E-01  7.9363E-01  7.9496E-01»
 7.6904E-01  7.6904E-01
 7.7002E-01  7.7002E-01  7.7002E-01

  7   buck(SAND)simp-support general buck; MIDLENGTH =
 7.4445E-01  5.7575E-01  4.2605E-01  2.6993E-01  2.7976E-01  1.6003E-01  1.6003E-01  5.8066E-04»
 4.7659E-02  1.6086E-02
-4.5303E-03  1.1878E-03  1.1875E-03 -8.9164E-03 -3.2609E-03 -1.5319E-02 -7.1854E-03 -5.4779E-03»
-5.4782E-03 -3.7529E-04
-2.0519E-03 -4.2861E-03 -5.3877E-03 -2.7314E-03 -2.7313E-03 -1.8590E-02 -4.2020E-03 -6.1650E-03»
 3.9427E-03  3.7763E-03
 7.7855E-04  7.7855E-04  7.7855E-04

  8   buck(SAND)rolling only of stringers; MIDLENGTH =
 3.8789E-01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00»
 0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00»
 0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00»
```

Table 1.68 rikscurved.OPP p3of5

```
0.0000E+00  0.0000E+00
0.0000E+00  0.0000E+00  0.0000E+00

      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»
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 2.6760E+01   NOT FEASIBLE  (0; 2)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
   2 2.5464E+01  ALMOST FEASIBLE(0; 1)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
   3 2.4148E+01  ALMOST FEASIBLE(0; 1)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
   4 2.2934E+01  MILDLY UNFEASIB(0; 1)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
   5 2.3349E+01  ALMOST FEASIBLE(0; 1)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
   6 2.2451E+01  ALMOST FEASIBLE(0; 1)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
 ----------------------------------------------------PANDAOPT
   7 2.2451E+01      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 2.0234E+01  MILDLY UNFEASIB(0; 3)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
   9 1.9723E+01  MILDLY UNFEASIB(0; 3)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
  10 2.0065E+01  ALMOST FEASIBLE(0; 3)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
  11 1.9966E+01      FEASIBLE   (0; 3)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
  12 1.9776E+01  ALMOST 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
  13 1.9776E+01      FEASIBLE   (0; 1)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
  14 1.8396E+01  ALMOST FEASIBLE(0; 3)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
  15 1.8270E+01      FEASIBLE   (0; 3)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
  16 1.8036E+01  ALMOST FEASIBLE(0; 3)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
  17 1.7930E+01      FEASIBLE   (0; 3)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
  18 1.7849E+01      FEASIBLE   (0; 3)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
 ----------------------------------------------------PANDAOPT
  19 1.7849E+01      FEASIBLE   (0; 2)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
  20 1.7339E+01      FEASIBLE   (0; 3)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
  21 1.7164E+01  ALMOST FEASIBLE(0; 3)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
  22 1.7062E+01      FEASIBLE   (0; 3)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
  23 1.7017E+01  ALMOST FEASIBLE(0; 3)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
  24 1.7024E+01      FEASIBLE   (0; 3)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
 ----------------------------------------------------PANDAOPT
  25 1.7024E+01      FEASIBLE   (0; 2)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
  26 1.6290E+01  ALMOST FEASIBLE(0; 3)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
  27 1.6398E+01      FEASIBLE   (0; 3)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
  28 1.6397E+01      FEASIBLE   (0; 3)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
  29 1.6425E+01      FEASIBLE   (0; 3)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
```

Table 1.68 rikscurved. OPP p.4 of 5

```
 0
 ---------------------------------------------------------PANDAOPT
  30 1.6425E+01      FEASIBLE   (0; 3)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
  31 1.6320E+01      FEASIBLE   (0; 3)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
 ---------------------------------------------------------PANDAOPT
  32 1.6320E+01      FEASIBLE   (0; 3)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
 ---------------------------------------------------------PANDAOPT
  33 1.6320E+01      FEASIBLE   (0; 3)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0

 IOBJAL,ITRPLT=    0   33; OBJMN0,OBJPLT(ITRPLT)=  1.6290E+01  1.6320E+01
 =============================================================================
0
  VALUES OF DESIGN VARIABLES CORRESPONDING TO BEST FEASIBLE DESIGN
 VAR. STR/ SEG. LAYER   CURRENT
 NO.  RNG  NO.   NO.     VALUE              DEFINITION
  1         0     0    3.624E+00        B(STR):stiffener spacing, b: STR seg=NA, layer=NA
  2   STR   2     0    1.208E+00       B2(STR):width of stringer base, b2 (must be > 0, see Help)»
: STR seg=2 , lay
  3   STR   3     0    1.392E+00        H(STR):height of stiffener (type H for sketch), h: STR se»
g=3 , layer=NA
  4   SKN   1     1    2.660E-02    T(1 )(SKN):thickness for layer index no.(1 ): SKN seg=1 , lay»
er=1
  5   STR   3     1    1.007E-01    T(2 )(STR):thickness for layer index no.(2 ): STR seg=3 , 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    1.632E+01   WEIGHT OF THE ENTIRE PANEL

 *************                          ************
 ******************** DESIGN OBJECTIVE *******************
 ****************************************************
0
  VALUES OF DESIGN VARIABLES CORRESPONDING TO ALMOST FEASIBLE DESI
 VAR. STR/ SEG. LAYER   CURRENT
 NO.  RNG  NO.   NO.     VALUE              DEFINITION
  1         0     0    3.963E+00        B(STR):stiffener spacing, b: STR seg=NA, layer=NA
  2   STR   2     0    1.321E+00       B2(STR):width of stringer base, b2 (must be > 0, see Help)»
: STR seg=2 , lay
  3   STR   3     0    1.390E+00        H(STR):height of stiffener (type H for sketch), h: STR se»
g=3 , layer=NA
  4   SKN   1     1    2.882E-02    T(1 )(SKN):thickness for layer index no.(1 ): SKN seg=1 , lay»
er=1
  5   STR   3     1    1.036E-01    T(2 )(STR):thickness for layer index no.(2 ): STR seg=3 , 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    1.629E+01   WEIGHT OF THE ENTIRE PANEL

 *************                          ************
 ******************** DESIGN OBJECTIVE *******************
 ****************************************************
0
  VALUES OF DESIGN VARIABLES CORRESPONDING TO MILDLY UNFEASIB DESI
 VAR. STR/ SEG. LAYER   CURRENT
 NO.  RNG  NO.   NO.     VALUE              DEFINITION
  1         0     0    6.877E+00        B(STR):stiffener spacing, b: STR seg=NA, layer=NA
  2   STR   2     0    2.292E+00       B2(STR):width of stringer base, b2 (must be > 0, see Help)»
: STR seg=2 , lay
  3   STR   3     0    1.421E+00        H(STR):height of stiffener (type H for sketch), h: STR se»
g=3 , layer=NA
  4   SKN   1     1    5.499E-02    T(1 )(SKN):thickness for layer index no.(1 ): SKN seg=1 , lay»
er=1
```

optimum design used from now on in BIGBOSOR4 & STAGS models

Table 1.68 rikscurved.OPP (p.5 of 5)

```
  5   STR   3     1   1.157E-01    T(2 )(STR):thickness for layer index no.(2 ): STR seg=3 , 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   1.972E+01   WEIGHT OF THE ENTIRE PANEL

 *************                           ************
 ******************* DESIGN OBJECTIVE ******************
 *****************************************************
 ITYPE,ITRTOT,ITRMX2,IAUTOC,ITIGHT,IITIGH(1),ITRMIN(1)=
       1      33     150       0       0        0  100000
 ITYPE,ITRTOT,ITRMX2,IAUTOC,ITIGHT,IITIGH(2),ITRMIN(1)=
       1      33     300       0       0        0  100000
 ITYPE,ITRTOT,ITRMX2,IAUTOC,ITIGHT,IITIGH(3),ITRMIN(2)=
       1      33     430       0       0        0  100000


 DESCRIPTION OF FILES USED AND GENERATED IN THIS RUN:

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

 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  rikscurved.OPP FILE *****************
```

Table 1.69 rikscurved.CPL (input for CHOOSEPLOT)

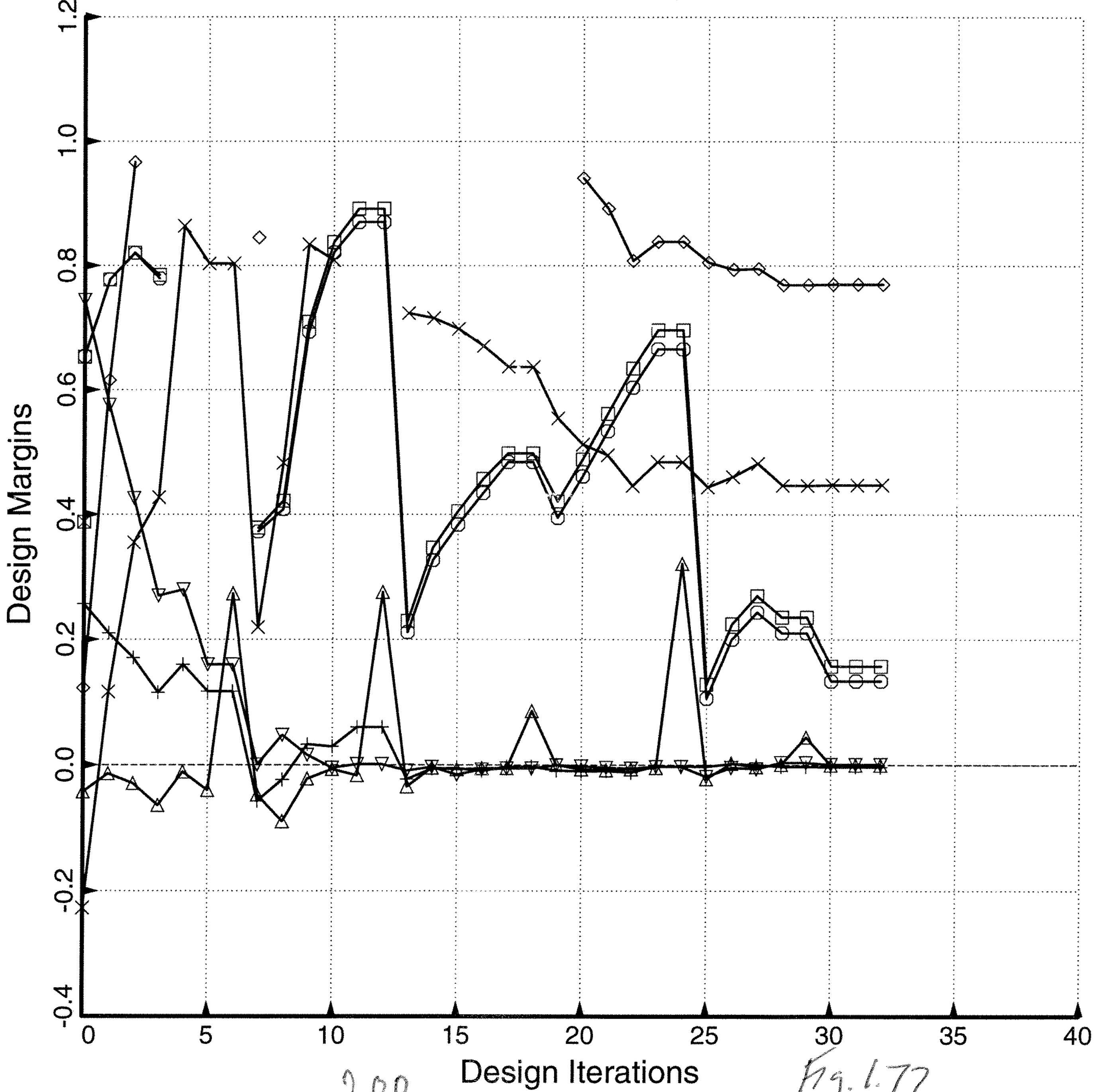
```
n        $ Do you want a tutorial session and tutorial output?
n        $ Any design variables to be plotted v. iterations (Y or N)?
y        $ Any design margins to be plotted (Y or N)?
   1     $ For which load set (1 - 5) do you want behavior/margins?
   1     $ Choose a sub-case (1 or 2) within 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,..)
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,..)
y        $ Any more margins to be plotted (Y or N) ?
   8     $ 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)?
```

margin no.
Loadset no.
Load subset no. (1 or 2)

rikscurved.3.ps
output from DIPLOT

□ 1 .1.1 Local buckling: discrete model
○ 2 .1.1 Local buckling: Koiter theory.
△ 3 .1.1 Hi-axial-wave post-post-buckling of module
+ 4 .1.1 m=? lateral-torsional buckling
× 5 .1.1 buckling: stringer seg.3 . MIDLENGTH
◇ 6 .1.1 buckling: stringer seg.3 . NO POSTBK
▽ 7 .1.1 buck(SAND)simp-support general buck; MIDLENGTH
⊠ 8 .1.1 buck(SAND)rolling only of stringers; MIDLENGTH

rikscurved: LOADSET=1, SUBSET=1



200

Fig. 1.72