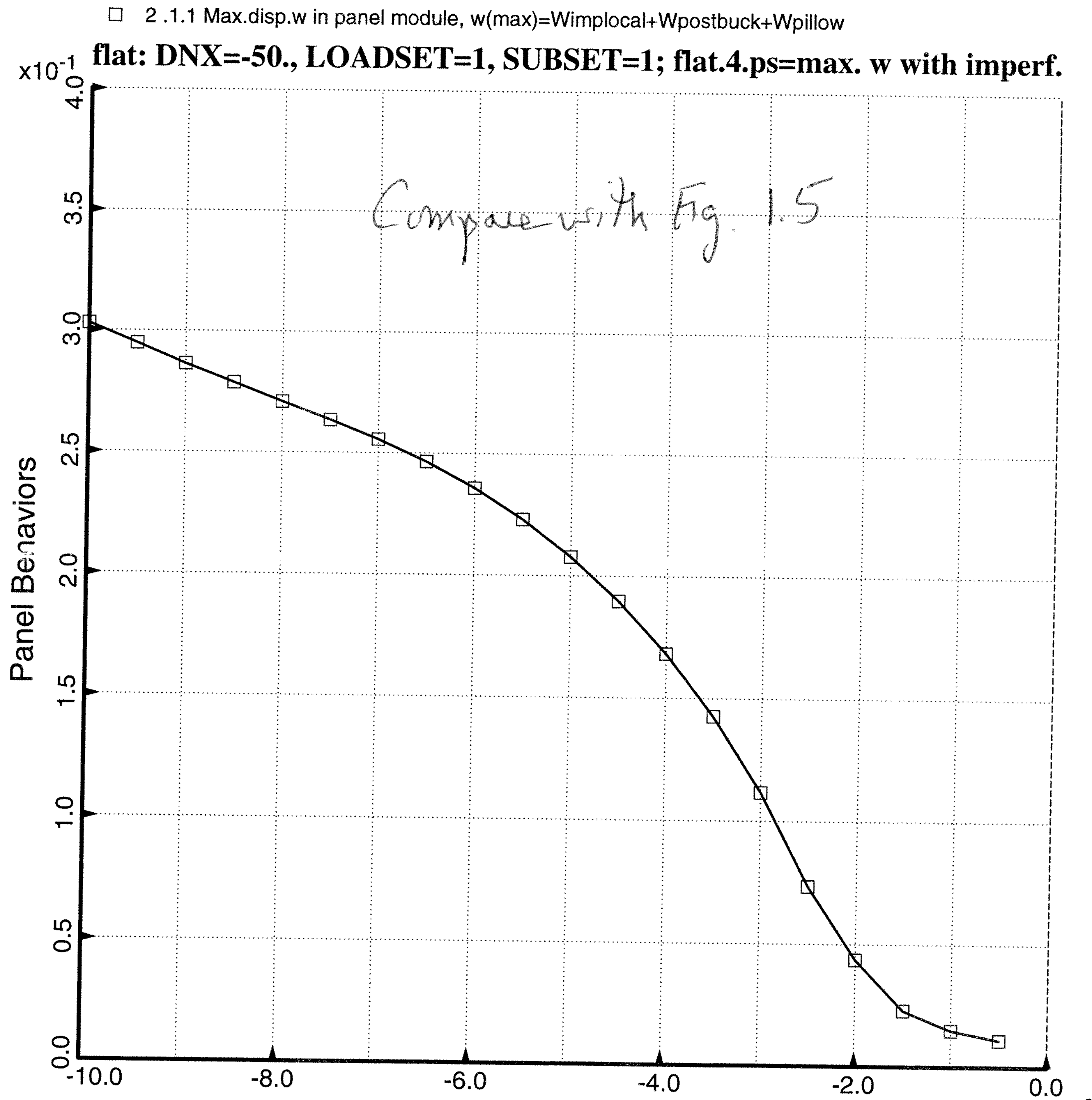
Table 1.16 flat.CPL = Flat.axial.cpl33

```
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?
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 for CHOOSEPLOT

flat.4.ps (with flat.cpl33 axial.) (imperfection included) 0.1"




52

Fig. 1.15

Table 1.17 flat.axial.stags.runstream

flat.axial.stags.runstream

29 June, 2008

This runstream is to generate STAGS input files, flat.bin and flat.inp, for the optimum design obtained by PANDA2 (except the thickness is slightly different: 0.087041 inch here instead of the latest optimum value found on 29 June, 2008: 0.085811 inch, as seen from the flat.OPP file.)

Table 1.2 Table 1.10 Table 1.3 Table 1.18 Table 1.19

```
panda2log
begin           (input = flat.BEG)
change          (cp flat.axial.chg flat.CHG; input = flat.CHG)
setup
decide          (input = flat.DEC)
mainsetup       (cp flat.axial.itype2.opt flat.OPT; input=flat.OPT)
pandaopt
stagsunit       (generate STAGS input files.
                 cp flat.axial.stg flat.STG; Input = flat.STG)
```

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

(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 equilibrium analysis 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.)

Tables 1.20, 1.21
Figs 1.16-1.29

(Run the STAGS program)

Table 1.18 flat.OPT (fixed design)

```
      n         $ Do you want a tutorial session and tutorial output?
 -1000.000      $ 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?
 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.axial.itype2.opt

input for "MAINSETUP" & "PANDAOPT"

Table 1.19 flat.STG (flat.axial.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
0.2000000      $ 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
  -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?
      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"

STAGSUNIT produces input files, flat.bin & flat.inp, for STAGS

Table 1.20

flat.out2 (abridged output from STAGS)

```
 CONVERGENCE HAS BEEN OBTAINED FOR EIGENVALUES  1 THROUGH   1
                              CRITICAL LOAD FACTOR COMBINATION
   NO.     EIGENVALUE      LOAD SYSTEM A   LOAD SYSTEM B     @DOF
     1   2.383247E-01     2.383247E-01    0.000000E+00     4542
```

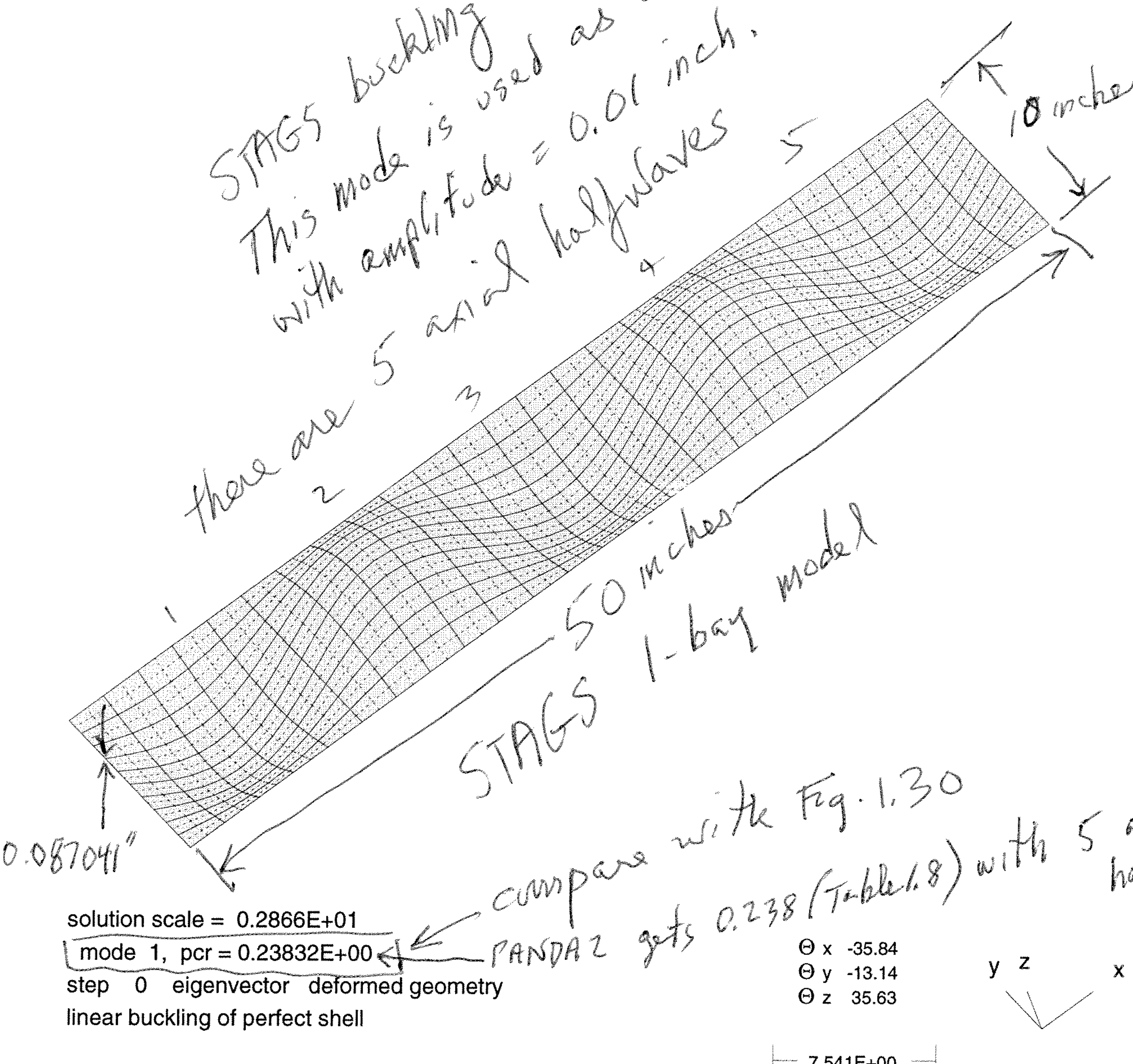
compare with PANDA2 result in Table 1.8

output from STAGS

output from (STAGS processor called STAPL

flat.linbuck.deformed.axialload.plf

STAGS buckling mode for pure axial compression
This mode is used as an initial imperfection shape
with amplitude = 0.01 inch.
there are 5 axial halfwaves




compare with Fig. 1.30

PANDA2 gets 0.238 (Table 1.8) with 5 axial halfwaves.



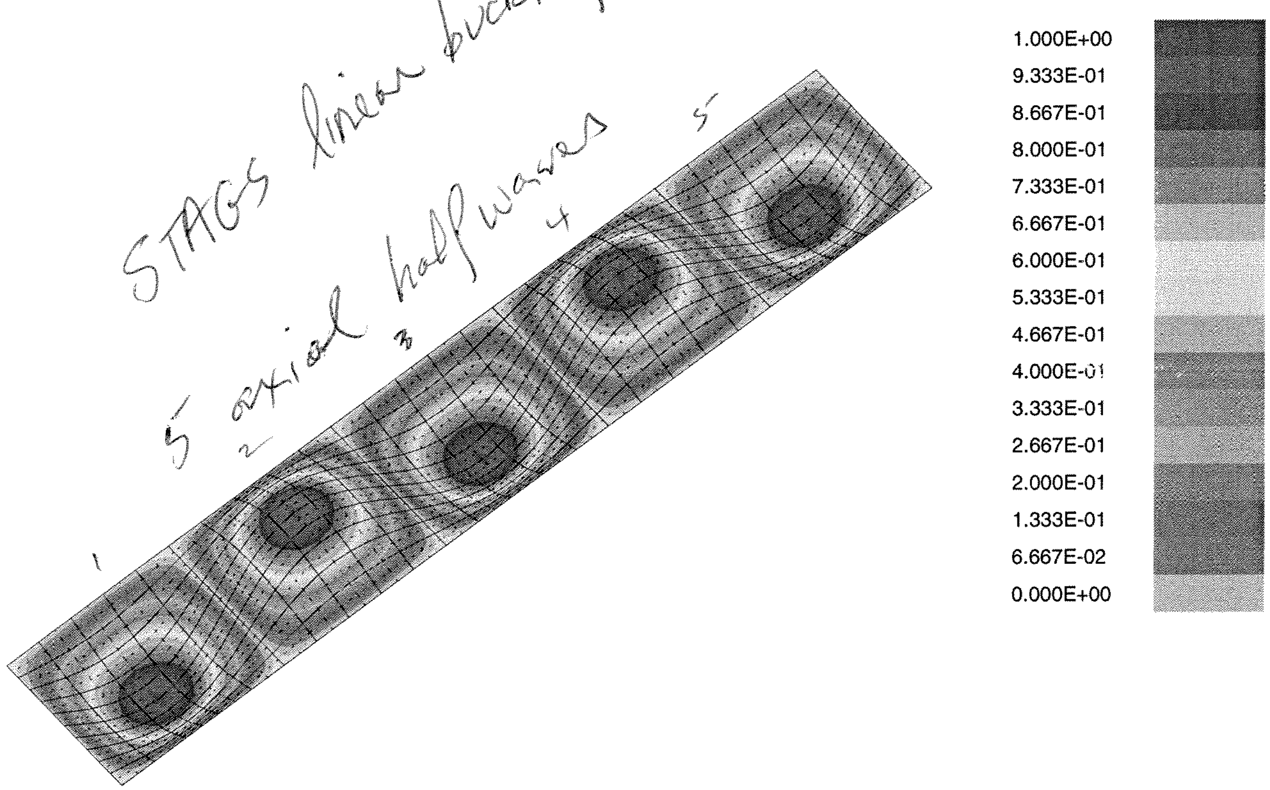
Fig. 1.16

flat.linbuck.wfringe.axialload.pdf

output from STAPL

STAGS linear buckling mode: fringe plot

5 axial halfwaves




solution scale = 0.2866E+01
mode 1, pcr = 0.23832E+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



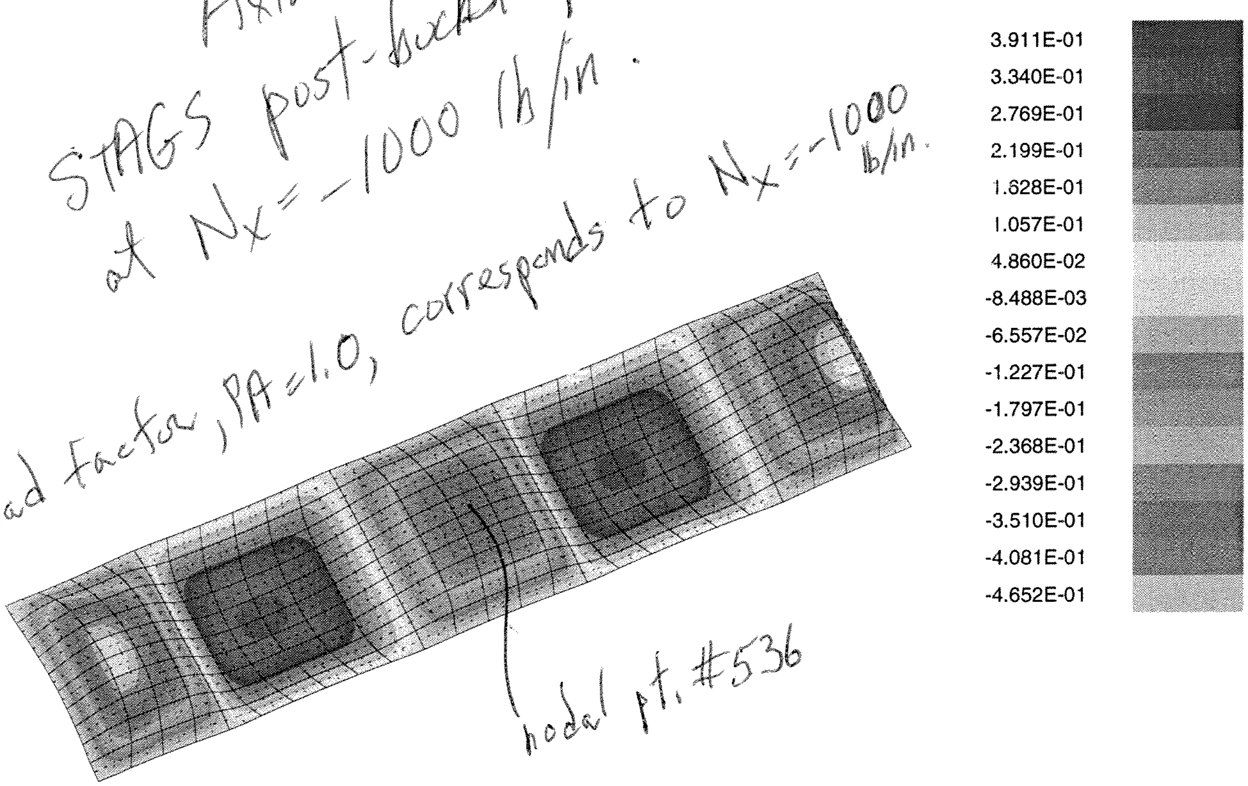
Fig 1.17

flat.postbuck.wFringe.axialload.pdf

output from STAPL

Axial Compression
STAGS post-buckling deformation
at $N_x = -1000$ lb/in.

Load factor, PA=1.0, corresponds to $N_x = -1000$ lb/in.




solution scale = 0.5662E+01

$\boxed{\text{PA= 1.00000E+00}}$ PB= 0.00000E+00 PX= 0.00000E+00

step 19 displacement w contours

nonlinear w

Minimum value = -4.65177E-01, Maximum value = 3.91114E-01

Θ x 24.00
Θ y -22.00
Θ z 30.00

8.957E+00

y x z



Fig. 1.18

Table 1.21 flataxial.w. input

```
# flataxial.w.input (input to the application, /home/progs/bin/plotps.linux )
# This is a typical file from which a postscript file, flataxial.w.ps, is generated.
# The "x,y" input data come from STAGS results generated via the STAGS processor
# called "xytrans" after completion of a STAGS nonlinear equilibrium run.
# In order to generate a postscript file that can be sent to a printer,
# type the command:
#  /home/progs/bin/plotps.linux < flataxial.w.input > flataxial.w.ps
# Global directives, load-deflection curve for "flat" with axial loading
=title(STAGS model of "flat": max. normal disp. w vs. axial load, Nx)
=xlabel(applied axial load, Nx (lb/in))
=ylabel(normal disp. w (in) at peak of middle bucking lobe: Nodal pt. 536))
# data set 1 Prediction from STAGS model generated via STAGSUNIT.
+legend(Prediction from STAGS model generated via STAGSUNIT)
+setmarker( 0)
   0.000000E+00    0.000000E+00
  -5.000000E+01    2.620284E-03
  -1.000000E+02    7.028825E-03
  -1.234391E+02    1.027677E-02
  -1.457843E+02    1.461480E-02
  -1.666521E+02    2.033483E-02
  -1.862669E+02    2.776360E-02
  -2.056330E+02    3.732372E-02
  -2.264906E+02    4.955518E-02
  -2.551880E+02    6.746682E-02
  -2.928614E+02    8.988900E-02
  -3.446324E+02    1.174163E-01
  -4.151457E+02    1.503872E-01
  -5.067315E+02    1.886754E-01
  -6.078911E+02    2.281818E-01
  -7.389041E+02    2.747269E-01
  -8.209169E+02    3.006847E-01
  -8.948581E+02    3.236259E-01
  -9.699078E+02    3.467873E-01
  -1.000000E+03    3.560172E-01
```

← Read this!

These "x, y" values are from a STAGS processor called "XYTRANS"

input for ...pandaz/bin/plotps.linux

which you have at your facility.

results from STAGS.

flataxial.w.{input / ps} ← output from ...panda2/bin/plotps.linux

□ Prediction from STAGS model generated via STAGSUNIT

**STAGS model of "flat": max. normal disp. w vs. axial load, Nx**

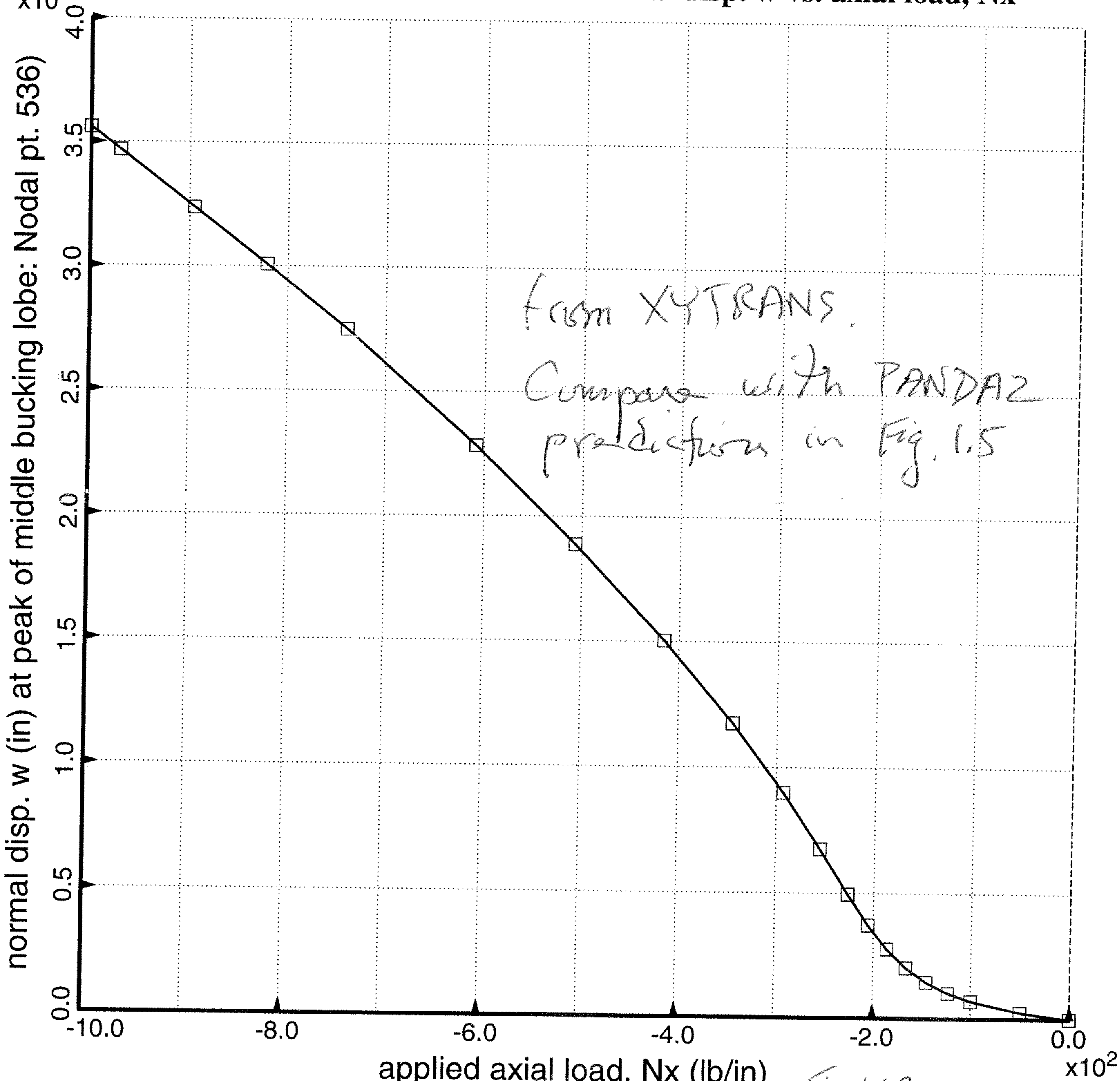
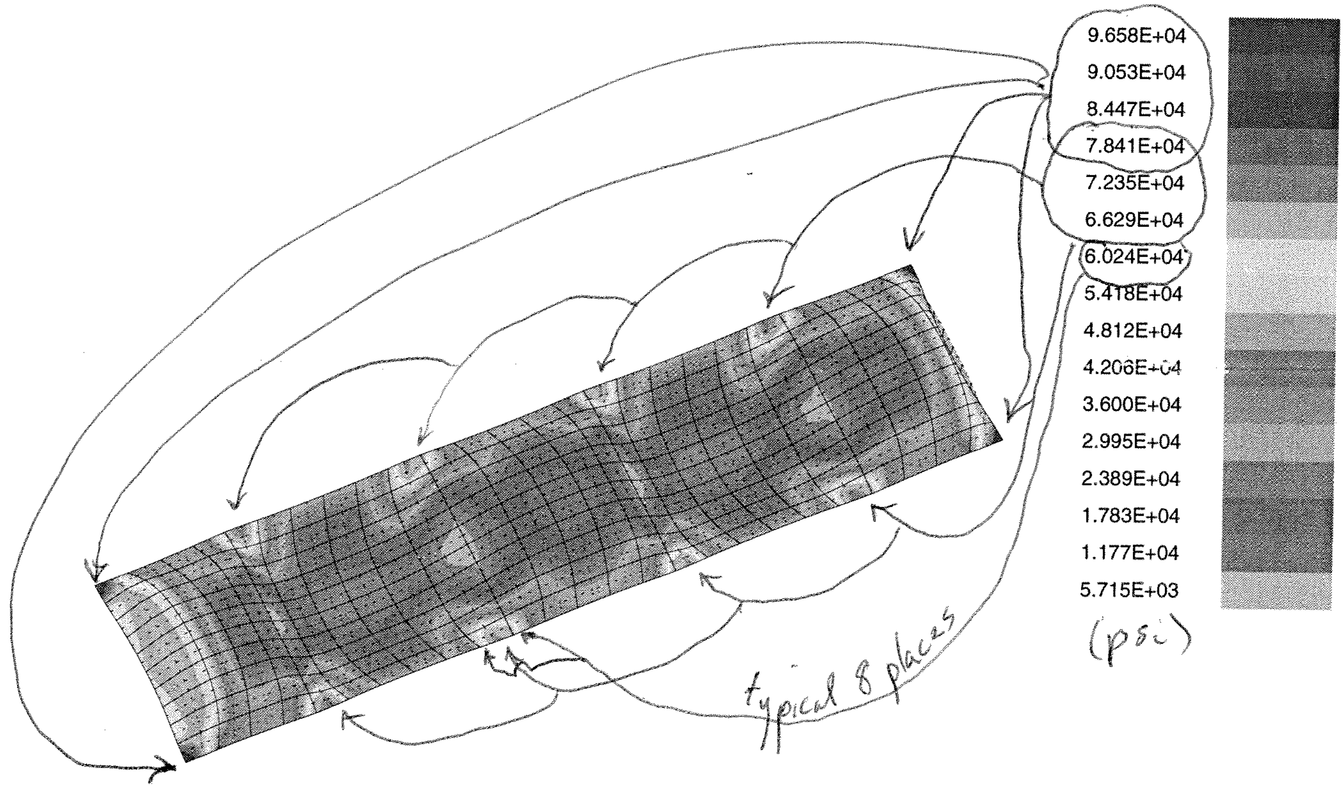



Fig 1.19

flat.postbuck.seff.innerfiber.axialload.pdf

output from STAGS

$N_x = -1000$ lb/in (PA=1.0)




solution scale = 0.5662E+01
PA= 1.00000E+00 PB= 0.00000E+00 PX= 0.00000E+00
step 19 fabrication system ,seff, layer 1, inner fiber
nonlinear effective stress - inner fiber "effective stress"
Minimum value = 5.71483E+03, Maximum value = 9.65842E+04

Θ x 24.00
Θ y -22.00
Θ z 30.00

8.957E+00

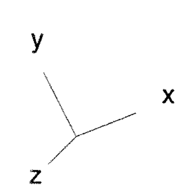
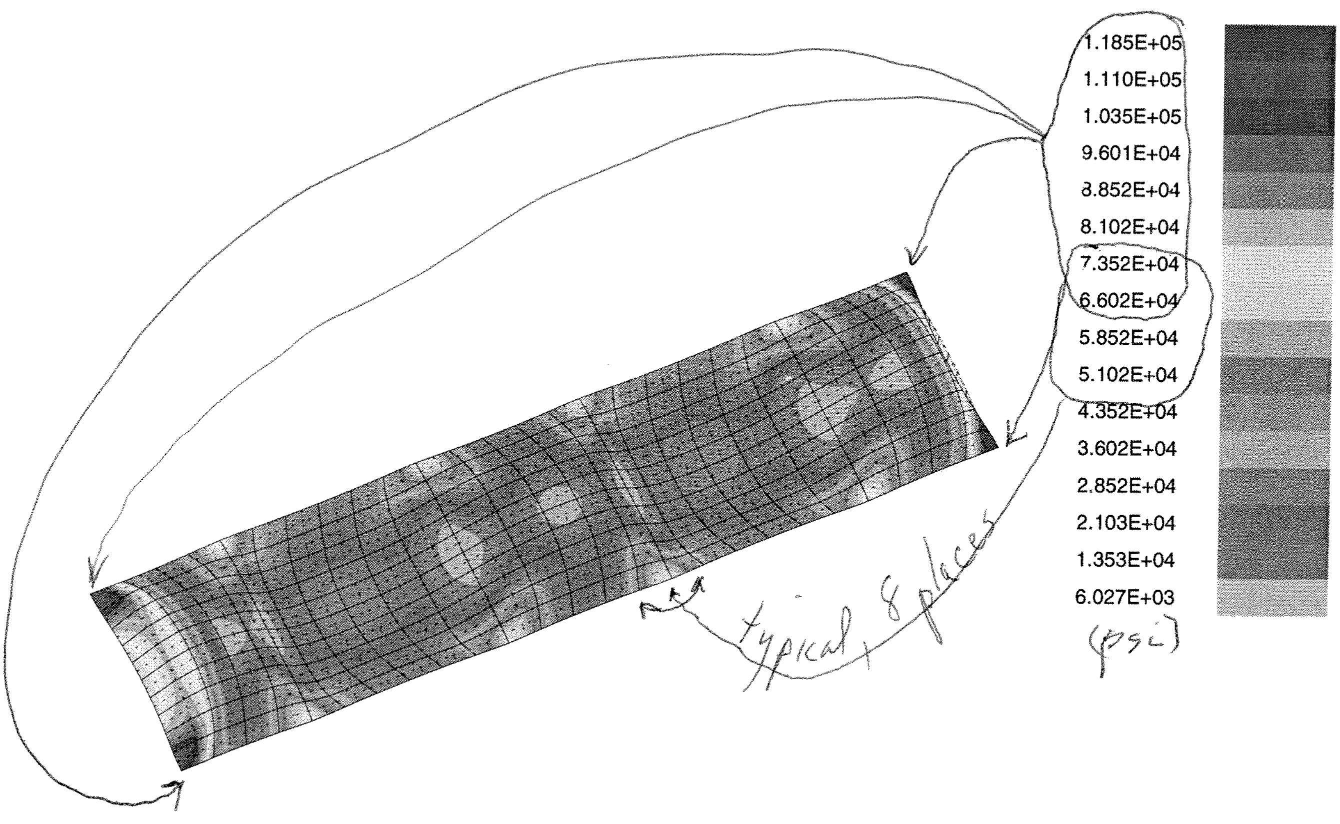





Fig.1.20

output from STAPL

$N_x = -1000$ lb/in




solution scale = 0.5662E+01
PA= 1.00000E+00 PB= 0.00000E+00 PX= 0.00000E+00
step 19 fabrication system ,seff, layer 1, outer fiber
nonlinear effective stress - outer fiber
Minimum value = 6.02728E+03, Maximum value = 1.18511E+05



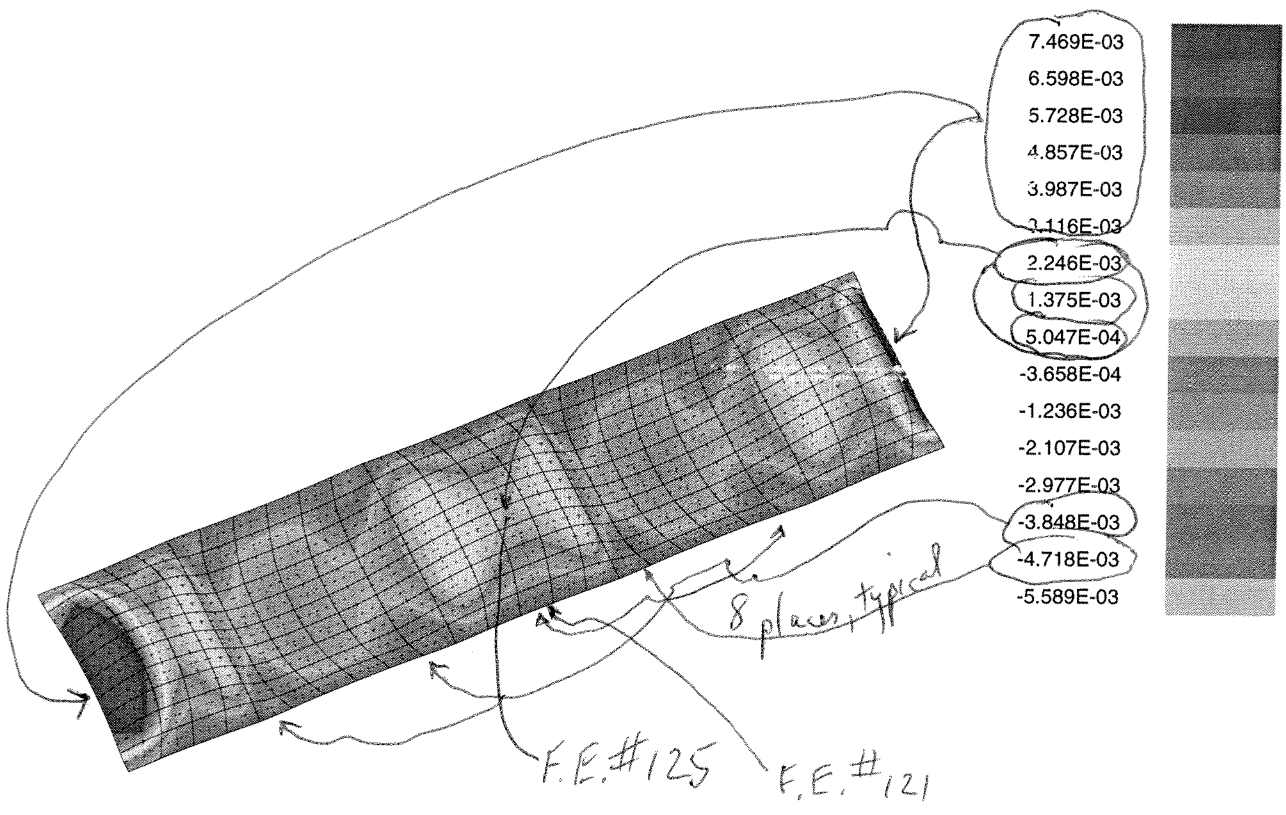
Fig 1.21

flat.postbuck, epsx.innerfiber, axialload.pdf

from STAPL

Pure axial compression,

$N_x = -1000$ lb/in




axial strain

solution scale = 0.5662E+01

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

step 19 strains , ex, layer 1, inner fiber

nonlinear axial strain - inner fiber

Minimum value = -5.58866E-03, Maximum value = 7.46855E-03

Θ x 24.00
Θ y -22.00
Θ z 30.00

y x z

8.957E+00

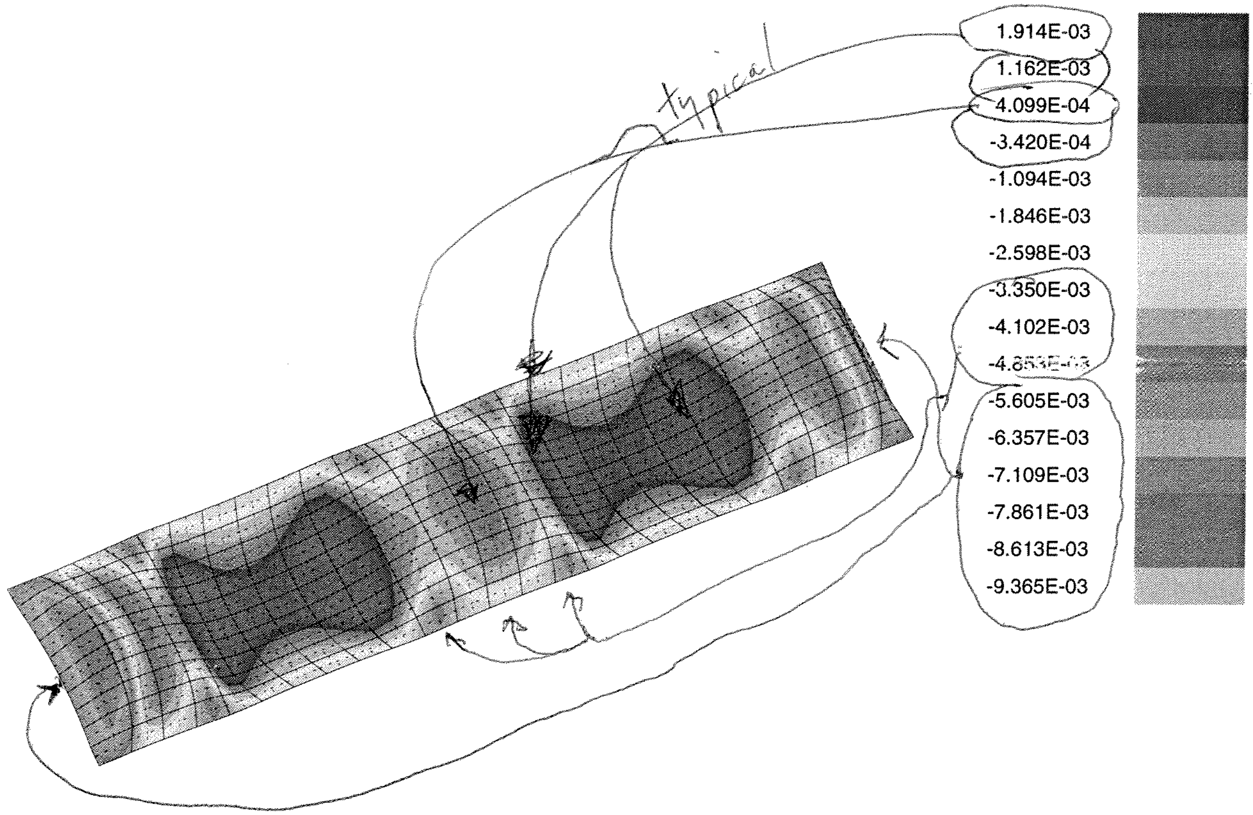


Fig. 1.22

flat.postbuck.epsx.outerfiber.axialload.pdf

from STAPL

$N_x = -1000$ lb/in




solution scale = 0.5662E+01
PA= 1.00000E+00 PB= 0.00000E+00 PX= 0.00000E+00
step 19 strains , ex, layer 1, outer fiber
nonlinear axial strain - outer fiber
Minimum value = -9.36488E-03, Maximum value = 1.91376E-03

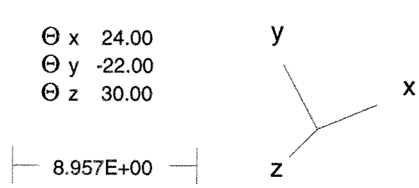





Fig. 1.23

□ axial strain epsx at integration pt. 1 of F.E. no. 125; bottom fiber at peak of buckle
○ axial strain epsx at integration pt. 2 of F.E. no. 125; bottom fiber at peak of buckle
△ axial strain epsx at integration pt. 3 of F.E. no. 125; bottom fiber at peak of buckle
+ axial strain epsx at integration pt. 4 of F.E. no. 125; bottom fiber at peak of buckle
× axial strain epsx at integration pt. 5 of F.E. no. 125; bottom fiber at peak of buckle
◇ axial strain epsx at integration pt. 6 of F.E. no. 125; bottom fiber at peak of buckle
▽ axial strain epsx at integration pt. 7 of F.E. no. 125; bottom fiber at peak of buckle
⊠ axial strain epsx at integration pt. 8 of F.E. no. 125; bottom fiber at peak of buckle
⋇ axial strain epsx at integration pt. 9 of F.E. no. 125; bottom fiber at peak of buckle
◈ axial strain epsx at integration pt. 1 of F.E. no. 125; top fiber at peak of buckle
⊕ axial strain epsx at integration pt. 2 of F.E. no. 125; top fiber at peak of buckle
⧖ axial strain epsx at integration pt. 3 of F.E. no. 125; top fiber at peak of buckle
⊞ axial strain epsx at integration pt. 4 of F.E. no. 125; top fiber at peak of buckle
⊠ axial strain epsx at integration pt. 5 of F.E. no. 125; top fiber at peak of buckle
◬ axial strain epsx at integration pt. 6 of F.E. no. 125; top fiber at peak of buckle
● axial strain epsx at integration pt. 7 of F.E. no. 125; top fiber at peak of buckle
○ axial strain epsx at integration pt. 8 of F.E. no. 125; top fiber at peak of buckle
□ axial strain epsx at integration pt. 9 of F.E. no. 125; top fiber at peak of buckle

**STAGS model of "flat": axial strain at buckle vx.axial load Nx**

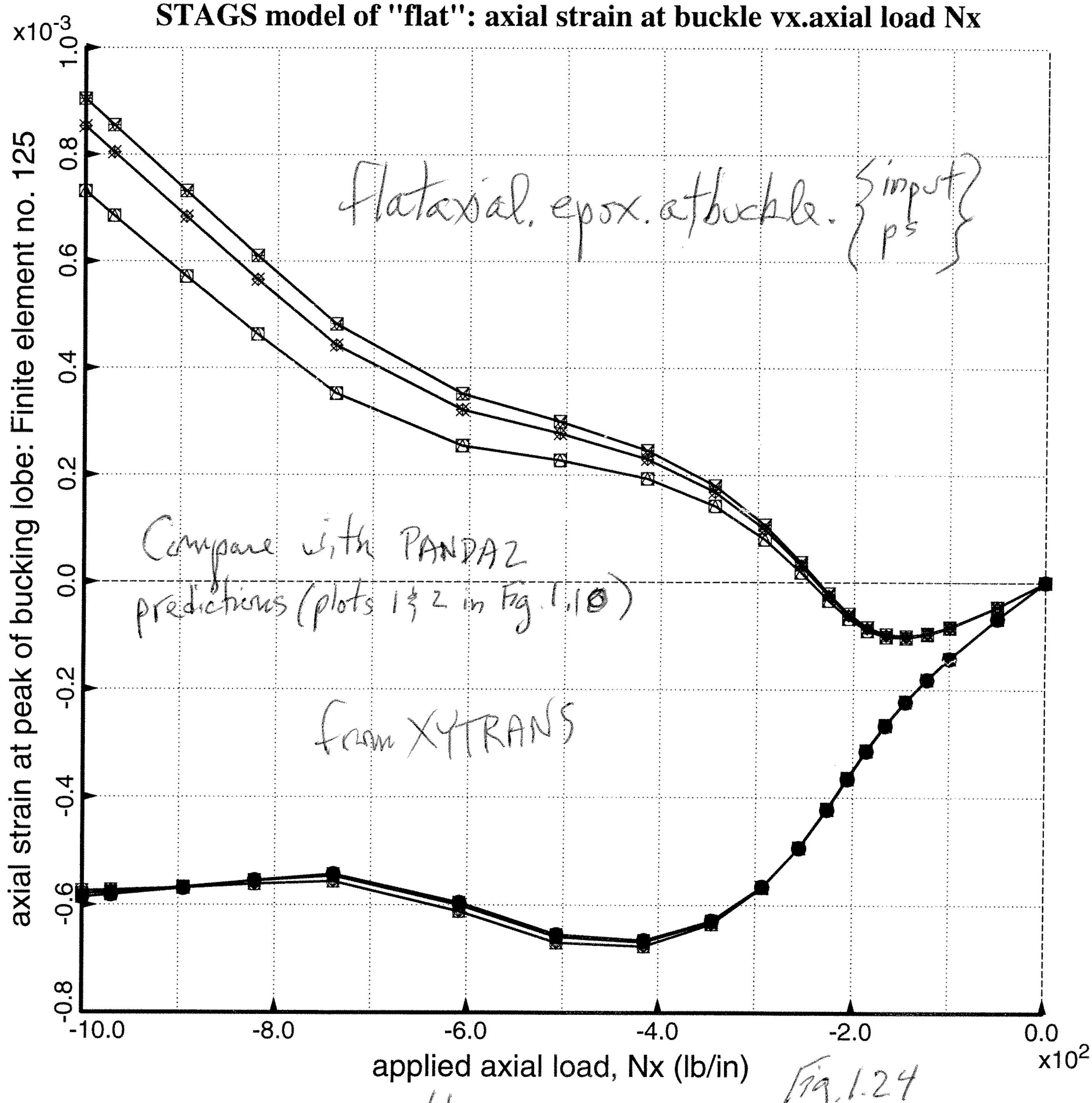



Fig. 1.24

□ 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

from XYTRANS

**STAGS model of "flat": axial strain near long edge vs.axial load, Nx**

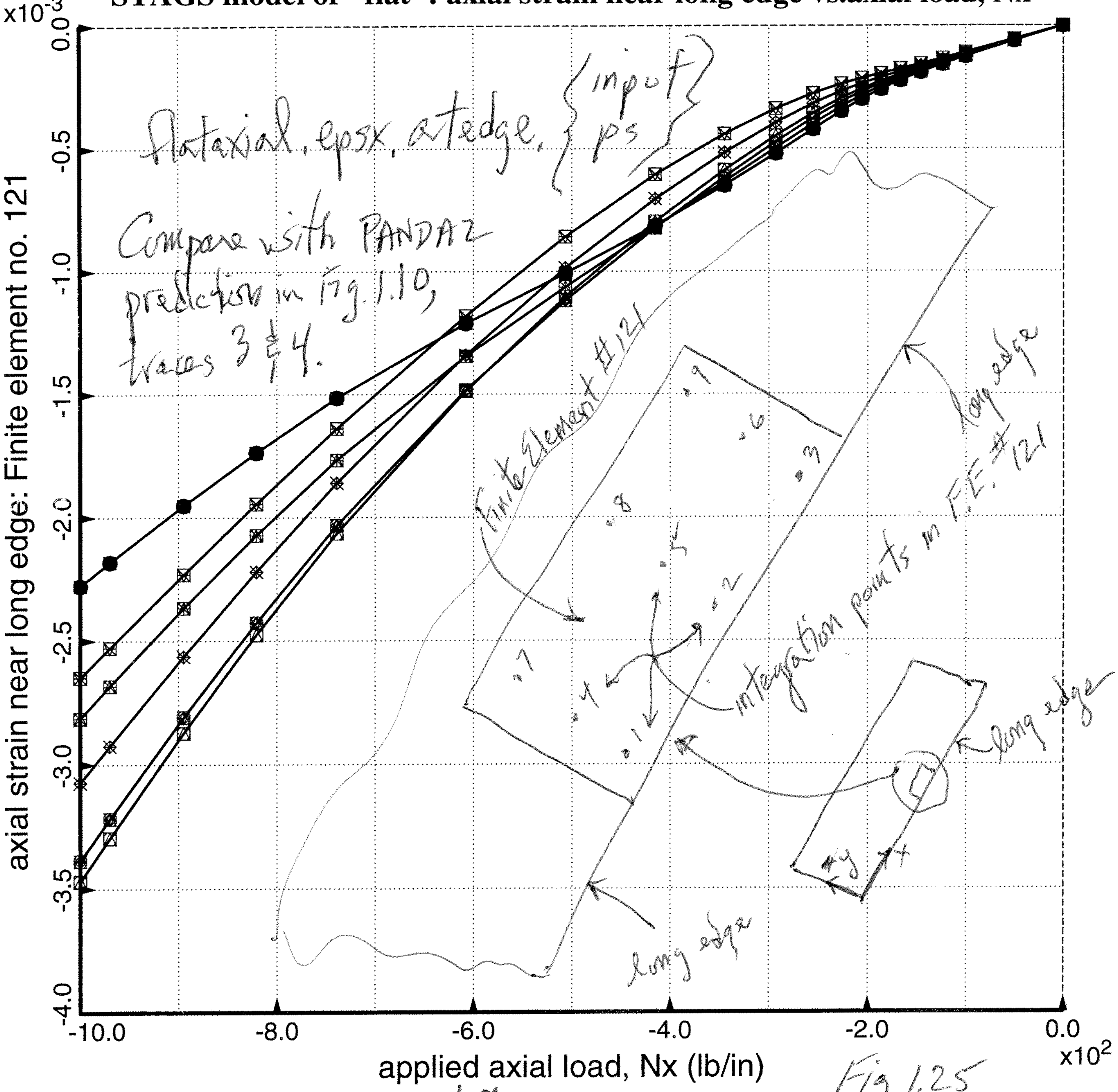
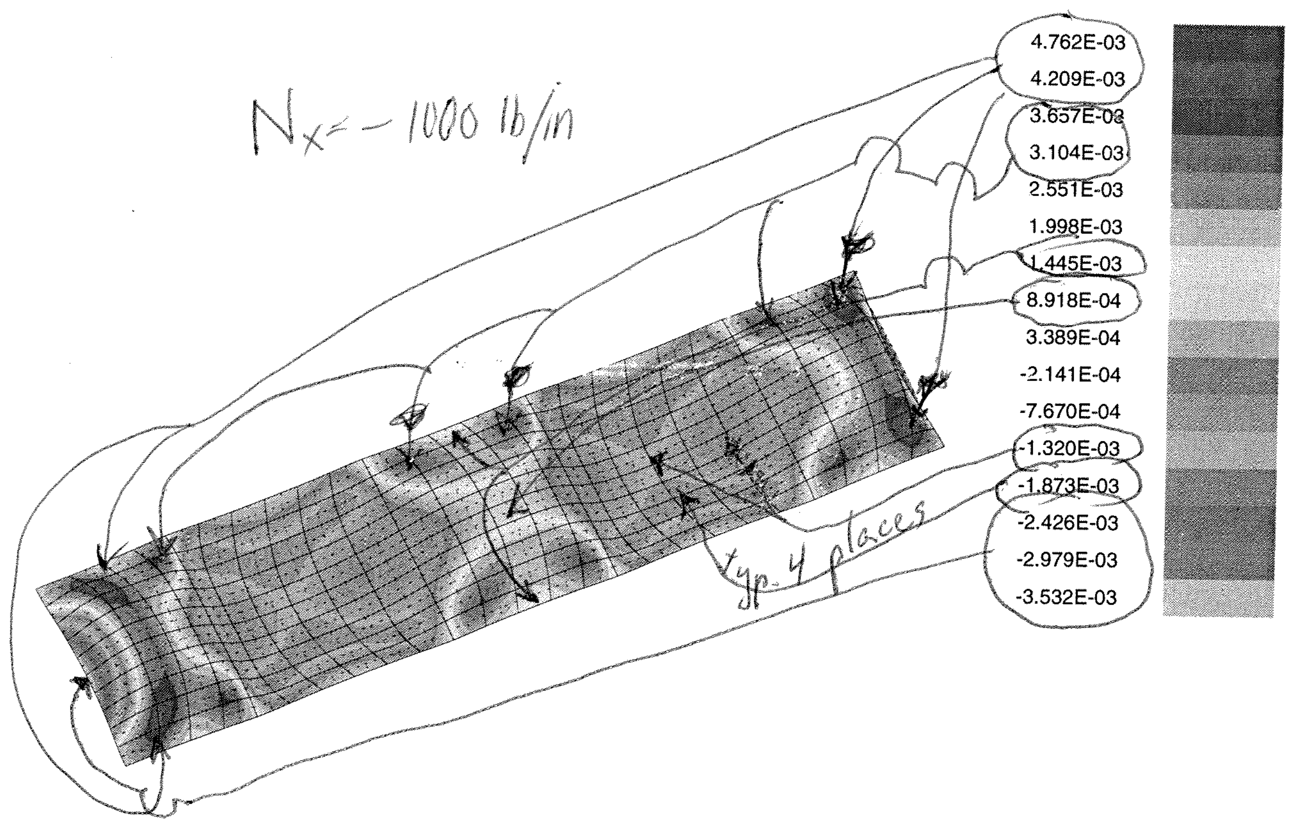



Fig. 1.25

flat.postbuck.epsy.innerfiber.axialload.pdf

from STAPL




solution scale = 0.5662E+01
PA= 1.00000E+00 PB= 0.00000E+00 PX= 0.00000E+00
step 19 strains , ey, layer 1, inner fiber
nonlinear hoop strain - inner fiber
Minimum value = -3.53169E-03, Maximum value = 4.76240E-03

Θ x 24.00
Θ y -22.00
Θ z 30.00

8.957E+00

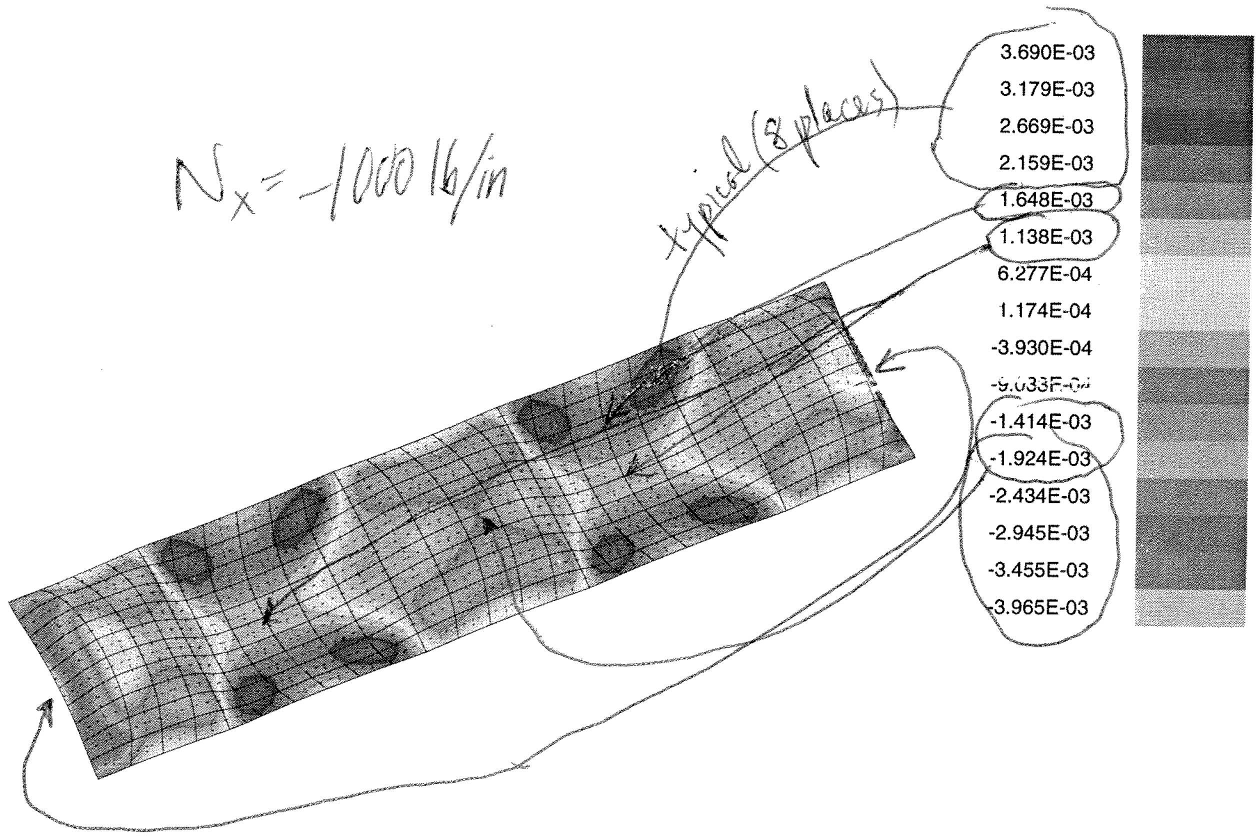
y x z

68

Fig. 1.26

flat.postbuck.epsy.outerfiber.axialload.pdf

from STAPL




solution scale = 0.5662E+01
PA= 1.00000E+00 PB= 0.00000E+00 PX= 0.00000E+00
step 19 strains , ey, layer 1, outer fiber
nonlinear hoop strain - outer fiber
Minimum value = -3.96540E-03, Maximum value = 3.68982E-03

Θ x 24.00
Θ y -22.00
Θ z 30.00

8.957E+00

y x z

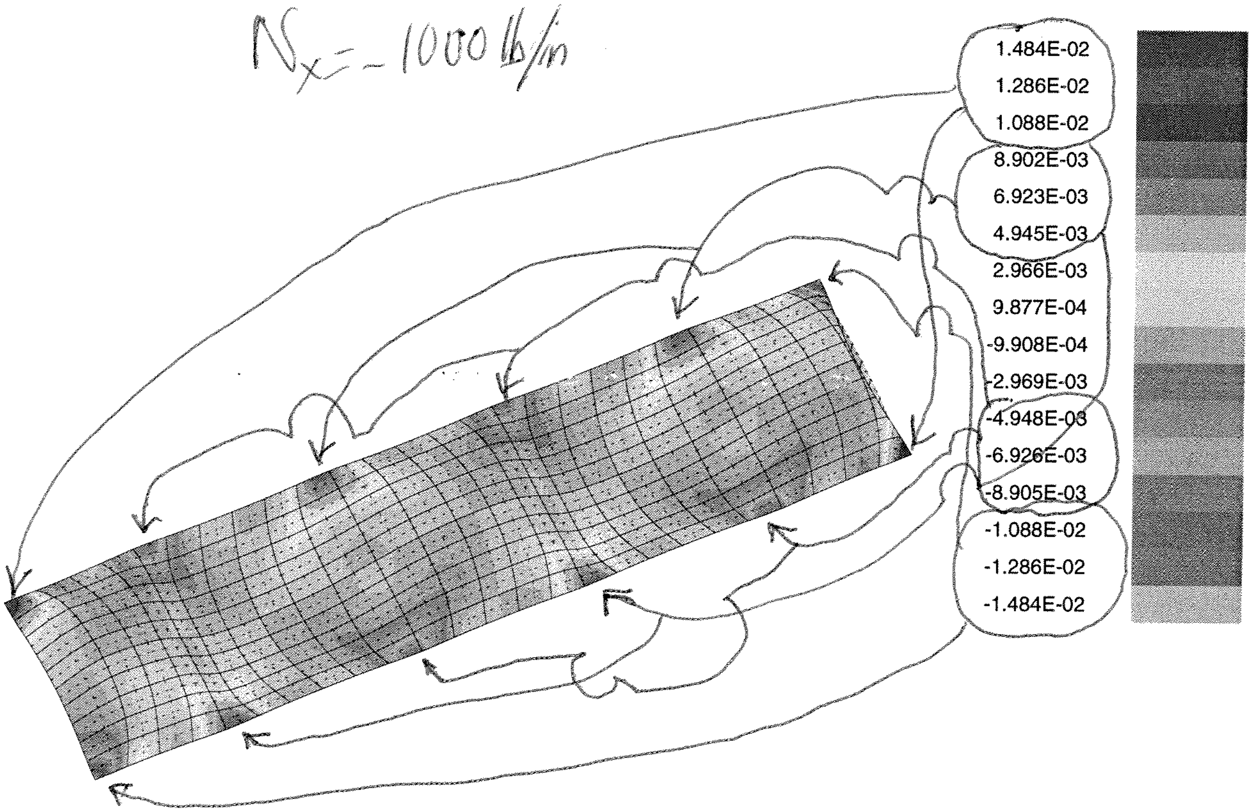


Fig. 1.27

flat.postbuck.epsxy.innerfiber.axialload.pdf

from STAPL

$N_x = -1000$ lb/in




solution scale = 0.5662E+01
PA= 1.00000E+00 PB= 0.00000E+00 PX= 0.00000E+00
step 19 strains , exy, layer 1, inner fiber
nonlinear in-plane shear strain - inner fiber
Minimum value = -1.48404E-02, Maximum value = 1.48373E-02

Θ x 24.00
Θ y -22.00
Θ z 30.00

8.957E+00

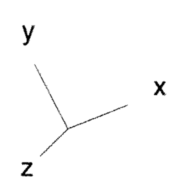





Fig. 1.28

flat.postbuck.epsxy.outerfiber.axialload.pdf

from STAPL

$N_x = -1000$ lb/in

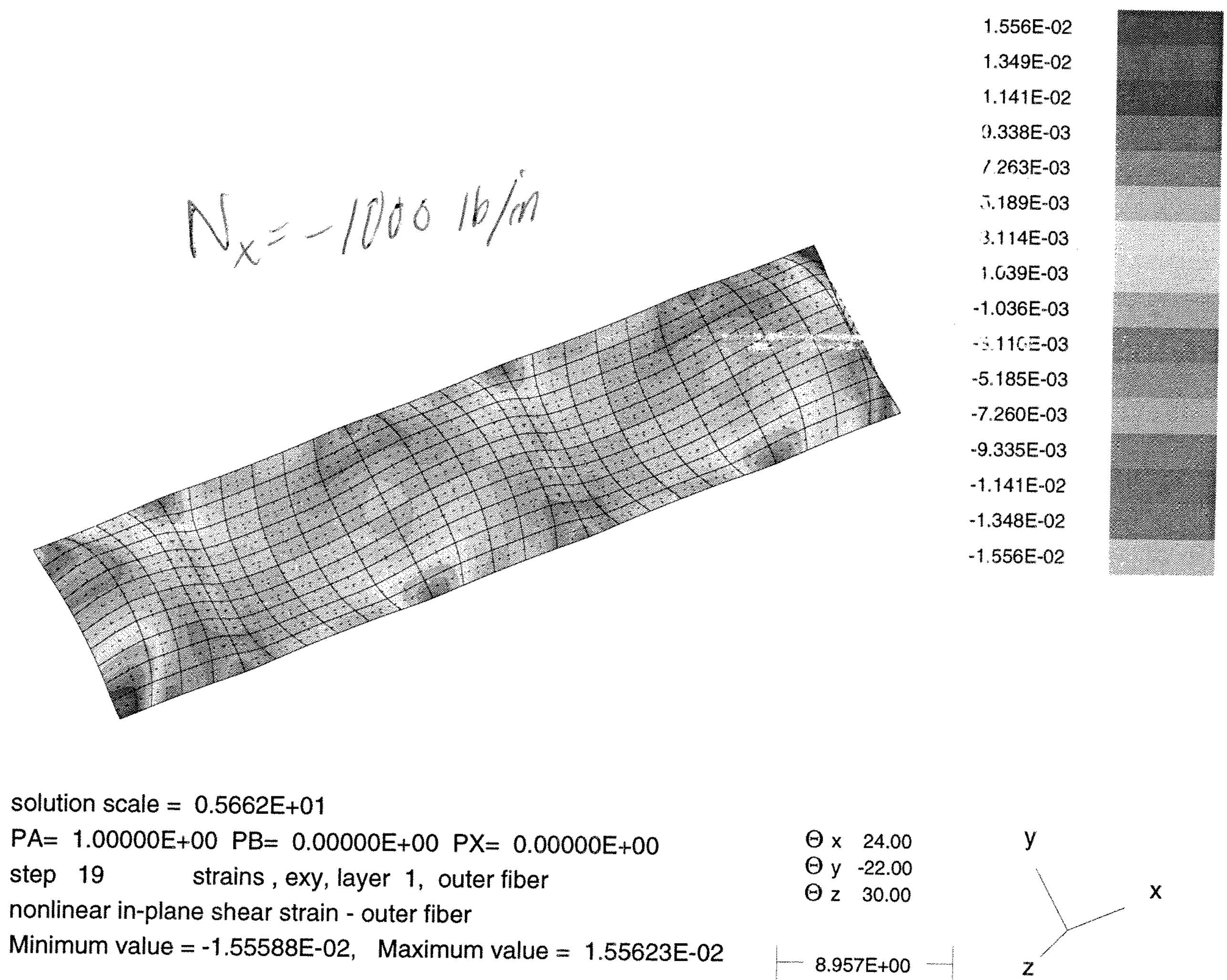





Fig. 1.29

Sub-section 1.2

Unstiffened Flat Plate

50 x 50 inches

$N_x = -1000$ lb/in

Table 1.22

Begin sub-section 1.2

riks.5bay.axial.stags.fakestiff.runstream

29 June, 2008

This runstream is to generate STAGS input files, riks.bin and riks.inp, for the 5-bay model of the flat plate. The PANDA2 5-bay model has very large stringers with very small modulus and the applied axial load, Nx, is very small in order to avoid general buckling. The STAGS 5-bay model replaces the very large stringers with line constraints on normal displacement w. This "trick" prevents general buckling and therefore permits a direct comparison of the behaviors of a 1-bay STAGS model with a 5-bay STAGS model with respect to local buckling and post-buckling between adjacent "fake" stringers.

There is no optimization for this "fakestiff" case.

```
panda2log
begin          (cp riks.fakestiff.beg riks.BEG; input = riks.BEG)
setup
decide         (cp riks.fakestiff.dec riks.DEC; input = riks.DEC)
mainsetup      (cp riks.fakestiff.opt riks.OPT; input = riks.OPT)
pandaopt
stagsunit      (cp riks.axial.fakestiff.5bay.stg riks.STG; input = riks.STG)
```

Table 1.23

Table 1.24

Table 1.25

Table 1.26

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

(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 equilibrium analysis 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.)

Figs 1.30 - 1.40

Table 1.23    riks.BEG (riks.fakestiff.beg)

```
        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)
          10.       $ 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?
  0.8704100E-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?
  0.5000000         $ 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)
        n           $ Is the panel curved in the plane of the screen (Y for cyls.)?
        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+02     $ Young's modulus,                    E( 2)
  0.3000000         $ Poisson's ratio,                   NU( 2)
       38.46        $ 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 ?
   1000000.         $ Maximum allowable effective stress in material type( 2)
        n           $ Do you want to take advantage of "bending overshoot"?
  0.0001000         $ weight density (greater than 0!) of material type( 2)
        n           $ Is lamina cracking permitted along fibers (type H(elp))?
           0        $ Prebuckling phase: choose 0=simple support or 1=clamping
           0        $ Buckling: choose 0=simple support or 1=clamping
```

note

note

note

input for "BEGIN"

Note the huge but very soft stringers.

Table 1.24 riks.DEC (riks.Fakestiff.dec)

```
    n          $ Do you want a tutorial session and tutorial output?
    n          $ Want to use default for thickness decision variables (type H(elp)?
       4       $ Choose a decision variable (1,2,3,...)
0.1000000E-01 $ Lower bound of variable no.( 4)
0.3000000      $ Upper bound of variable no.( 4)
    n          $ Any more decision variables (Y or N) ?
    n          $ Any 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?
```

input for "DECIDE"

Table 1.25 riks.OPT (riks.fakestiff.opt)

small load

Fixed design

```
         n         $ Do you want a tutorial session and tutorial output?
      -1.0         $ 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)
         N         $ 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)
  0.000001         $ 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)
```

input for "MAINSETUP" & "PANDAOPT" for fixed design.

Table 1.26 riks.STG (fake stiffeners)

```
        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
  0.2000000       $ 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
fake stiff. --> 5 $ 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
```

riks.axial.fakestiff.5bay.stg

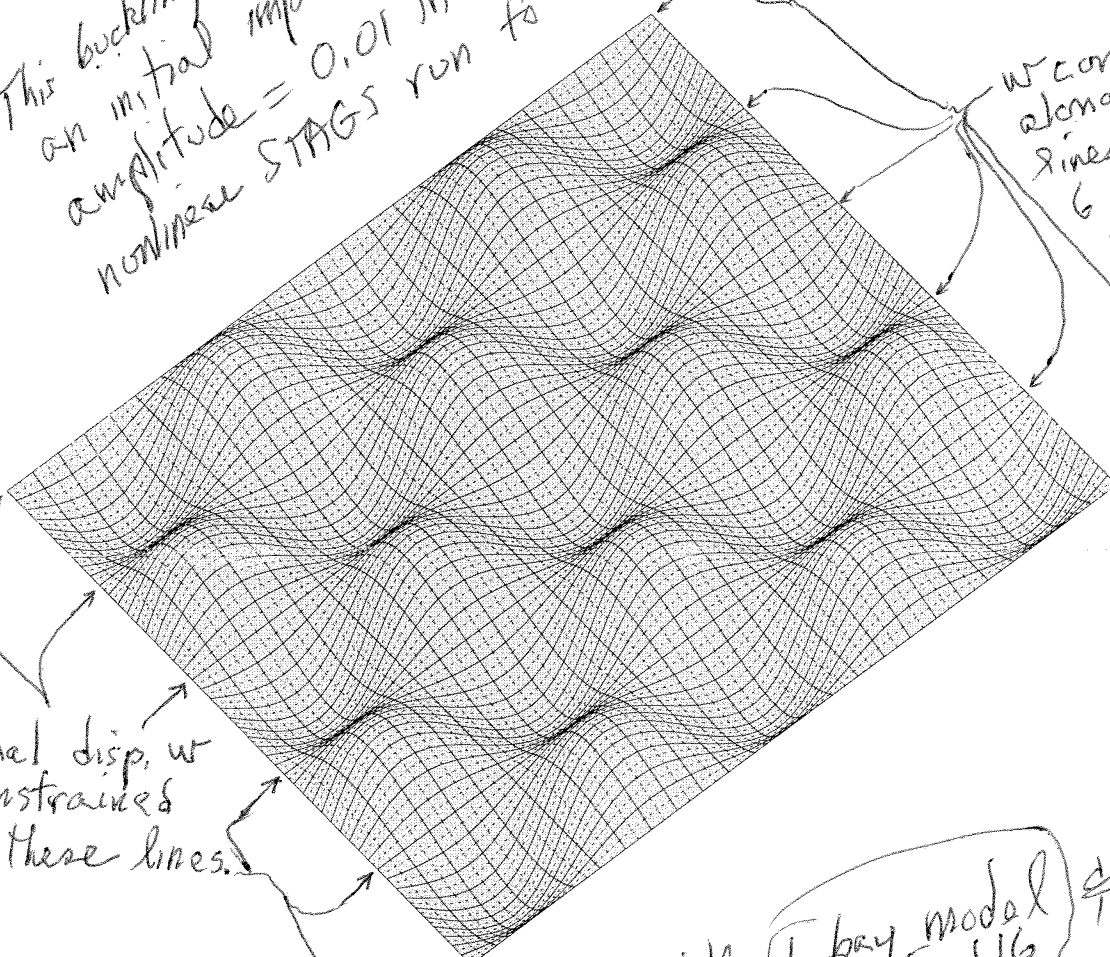
input for "STAGSUNIT" with use of "fake" stiffeners.

riks.linbuck.fakestiff.5bay.pdf

output from STAPL

This buckling mode shape is used as an initial imperfection, with amplitude = 0.01 inch, in the nonlinear STAGS run to follow.

w constrained along these 6 lines, simulating 6 stringers & preventing general buckling.

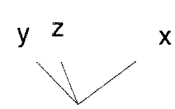


Normal disp. w is constrained along these lines.

compare with 1-bay model Fig. 1.16 & with PANDA2 Table 1.8

solution scale = 0.4303E+01
mode 1, $\boxed{\text{pcr = 0.23833E+00}}$
step 0 eigenvector deformed geometry
linear buckiing of perfect shell

Θ x -35.84
Θ y -13.14
Θ z 35.63




1.132E+01



Fig. 1.30

riksaxial.w.5bay.{input / ps}

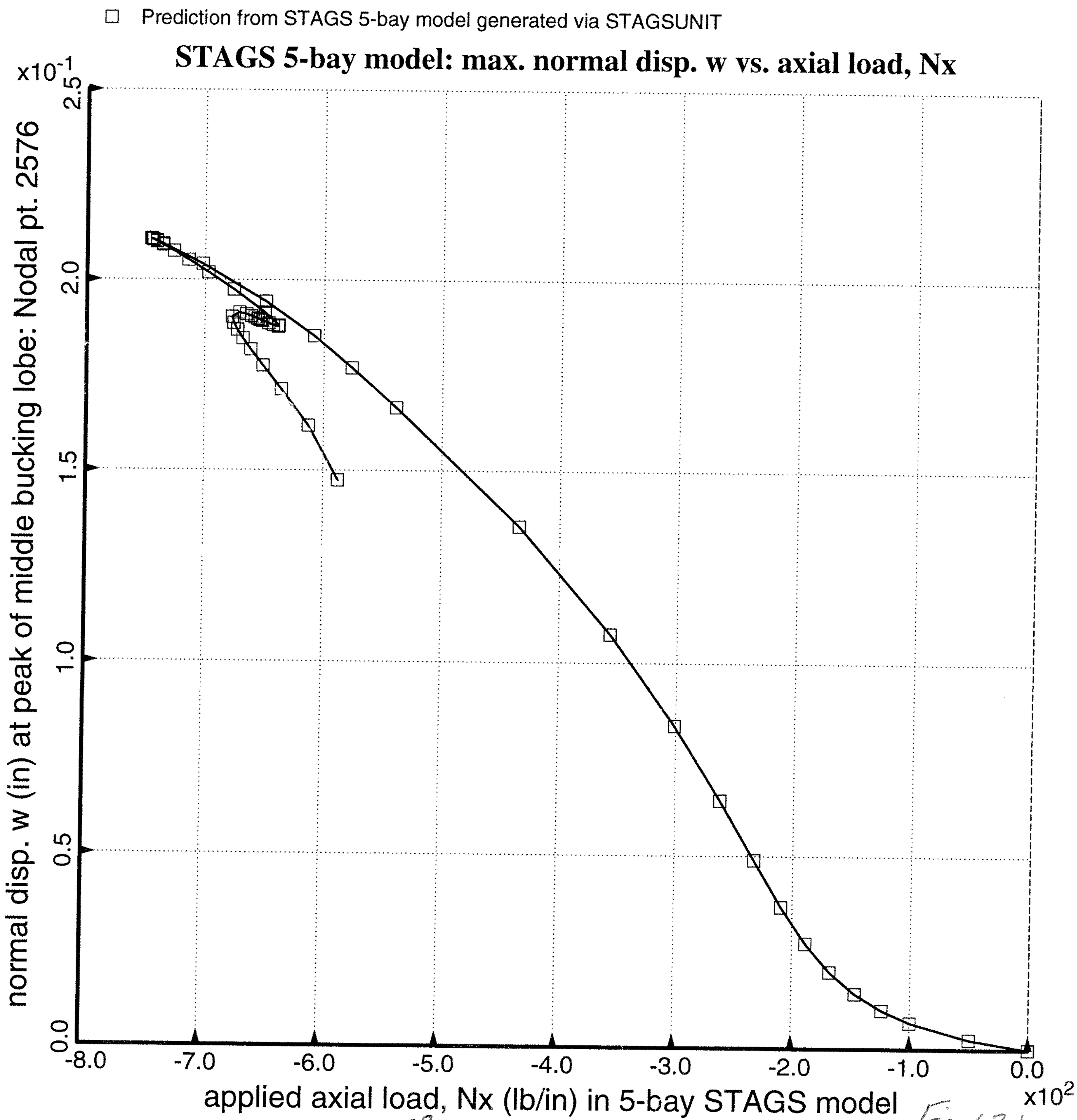
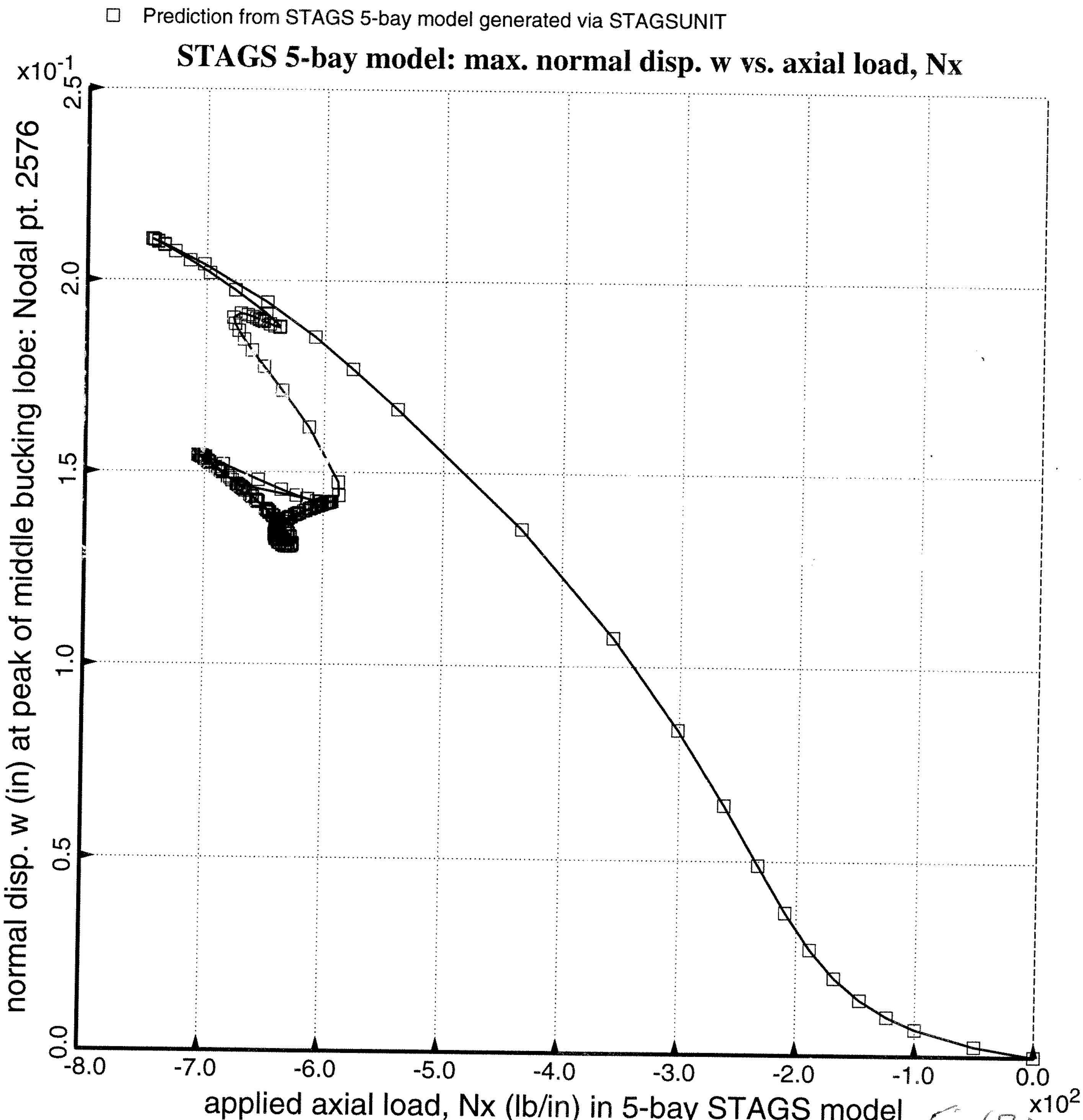




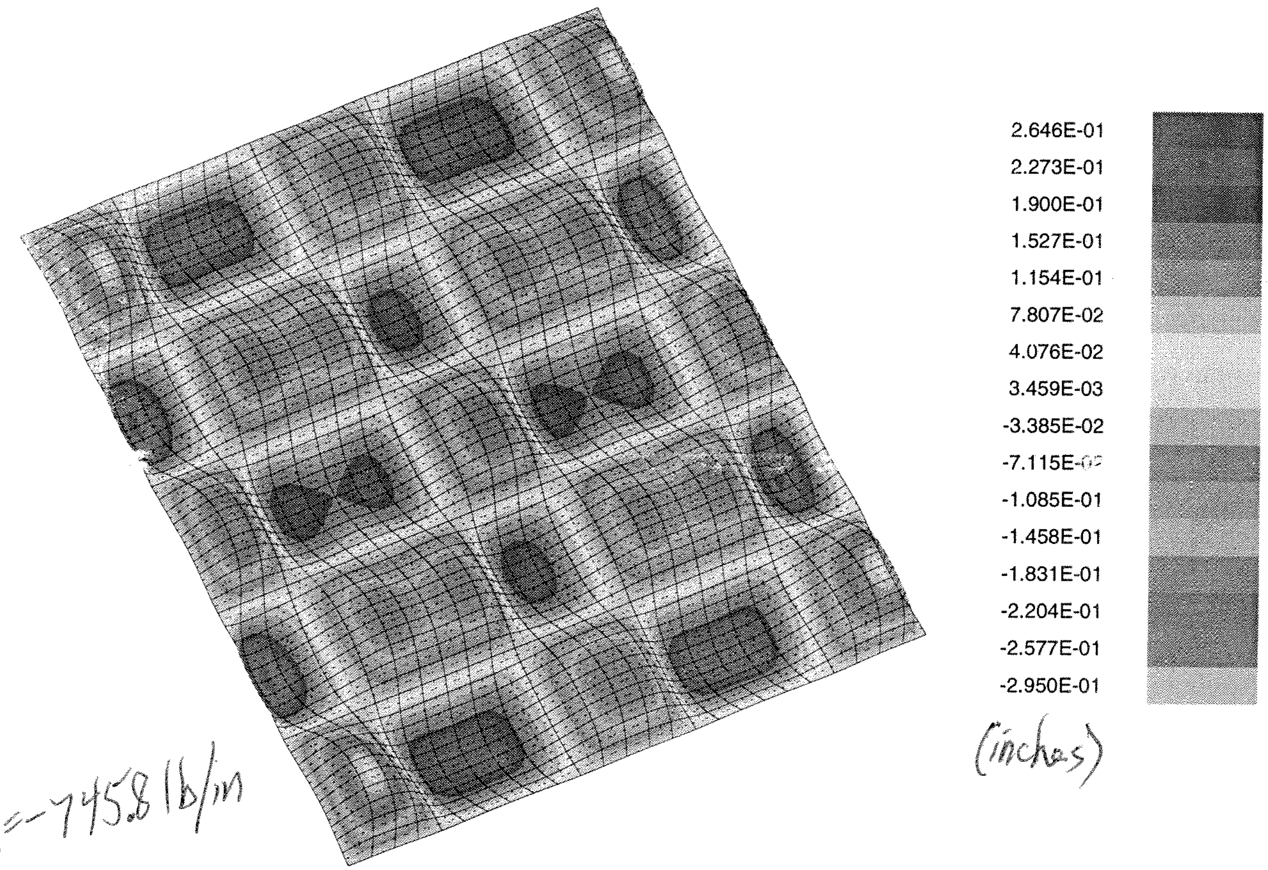

Fig. 1.31



Prediction from STAGS 5-bay model generated via STAGSUNIT
STAGS 5-bay model: max. normal disp. w vs. axial load, Nx
x10^-1
2.5
2.0
1.5
1.0
0.5
0.0
normal disp. w (in) at peak of middle bucking lobe: Nodal pt. 2576
-8.0
-7.0
-6.0
-5.0
-4.0
-3.0
-2.0
-1.0
0.0
x10^2
applied axial load, Nx (lb/in) in 5-bay STAGS model


Fig. 1.32

ribs.postbuck.fakestiff.5bay.step21.pdf




(inches)

$N_x = -745.8$ lb/in

solution scale = 0.1221E+02

PA= 7.45828E-01 PB= 0.00000E+00 PX= 0.00000E+00

step 21 displacement w contours

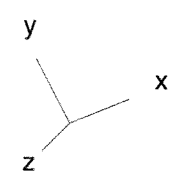
nonlinear w

Minimum value = -2.94981E-01, Maximum value = 2.64595E-01

Θ x 24.00

Θ y -22.00

Θ z 30.00

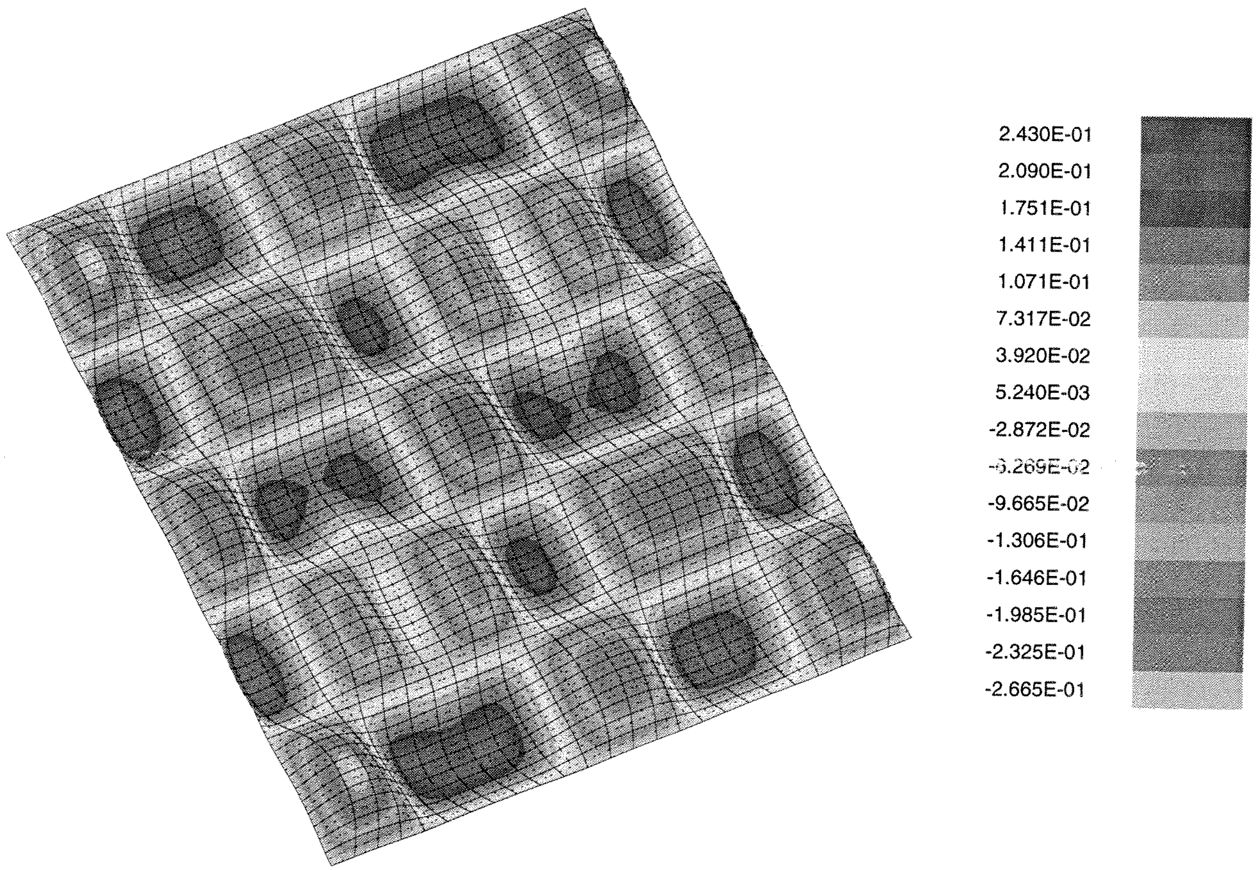



1.267E+01



Fig. 1.33

riks.postbuck.fakestiff.5bay.step42.pdf




solution scale = 0.1345E+02

PA= 6.77093E-01 PB= 0.00000E+00 PX= 0.00000E+00

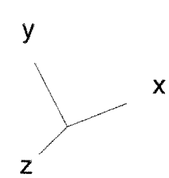
step 42 displacement w contours

nonlinear w

Minimum value = -2.66465E-01, Maximum value = 2.42982E-01

Θ x 24.00
Θ y -22.00
Θ z 30.00

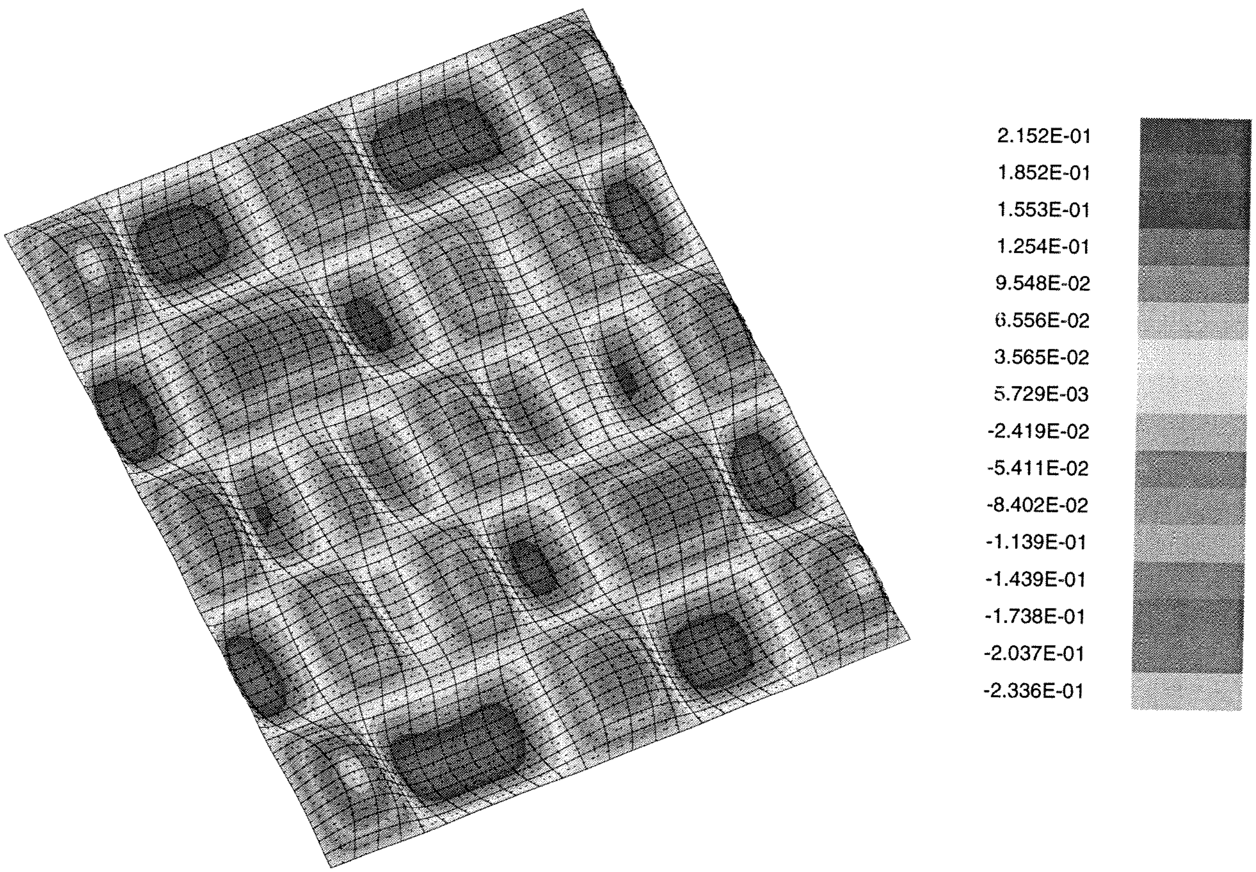
1.267E+01




82

Fig. 1.34

riks.postbuck.fakestiff.5bay.step79.pdf




solution scale = 0.1525E+02
$\boxed{\text{PA= 6.04384E-01}}$ PB= 0.00000E+00 PX= 0.00000E+00
$\boxed{\text{step 79}}$ displacement w contours
nonlinear w
Minimum value = -2.33613E-01, Maximum value = 2.15154E-01

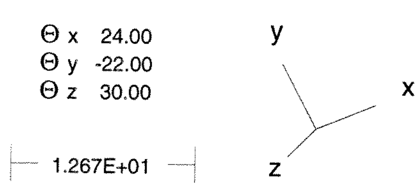
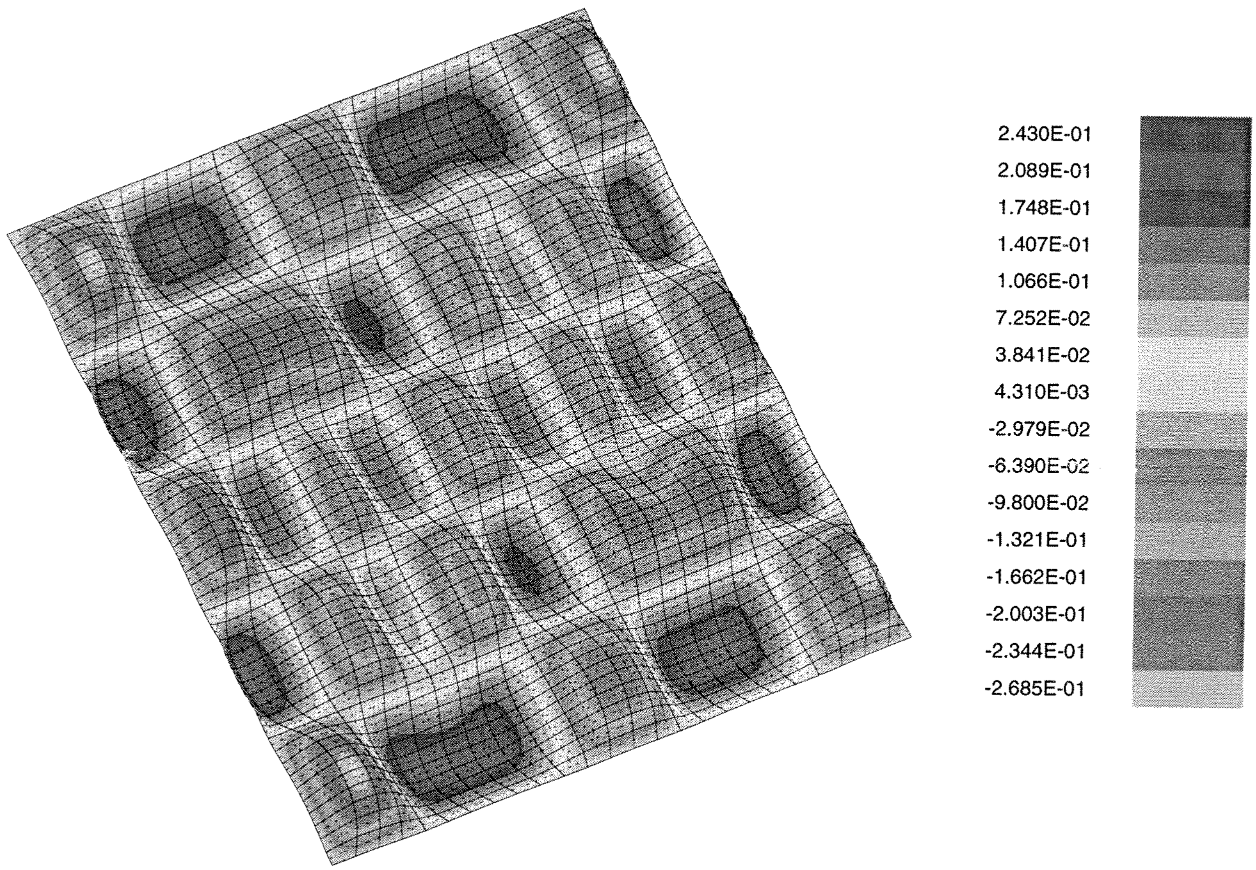





Fig. 1.35

riks.postbuck.fakestiff.5bay.step128.pdf




solution scale = 0.1335E+02

PA= 6.86686E-01 PB= 0.00000E+00 PX= 0.00000E+00

step 128 displacement w contours

nonlinear w

Minimum value = -2.68525E-01, Maximum value = 2.43040E-01

$\Theta$ x 24.00
$\Theta$ y -22.00
$\Theta$ z 30.00

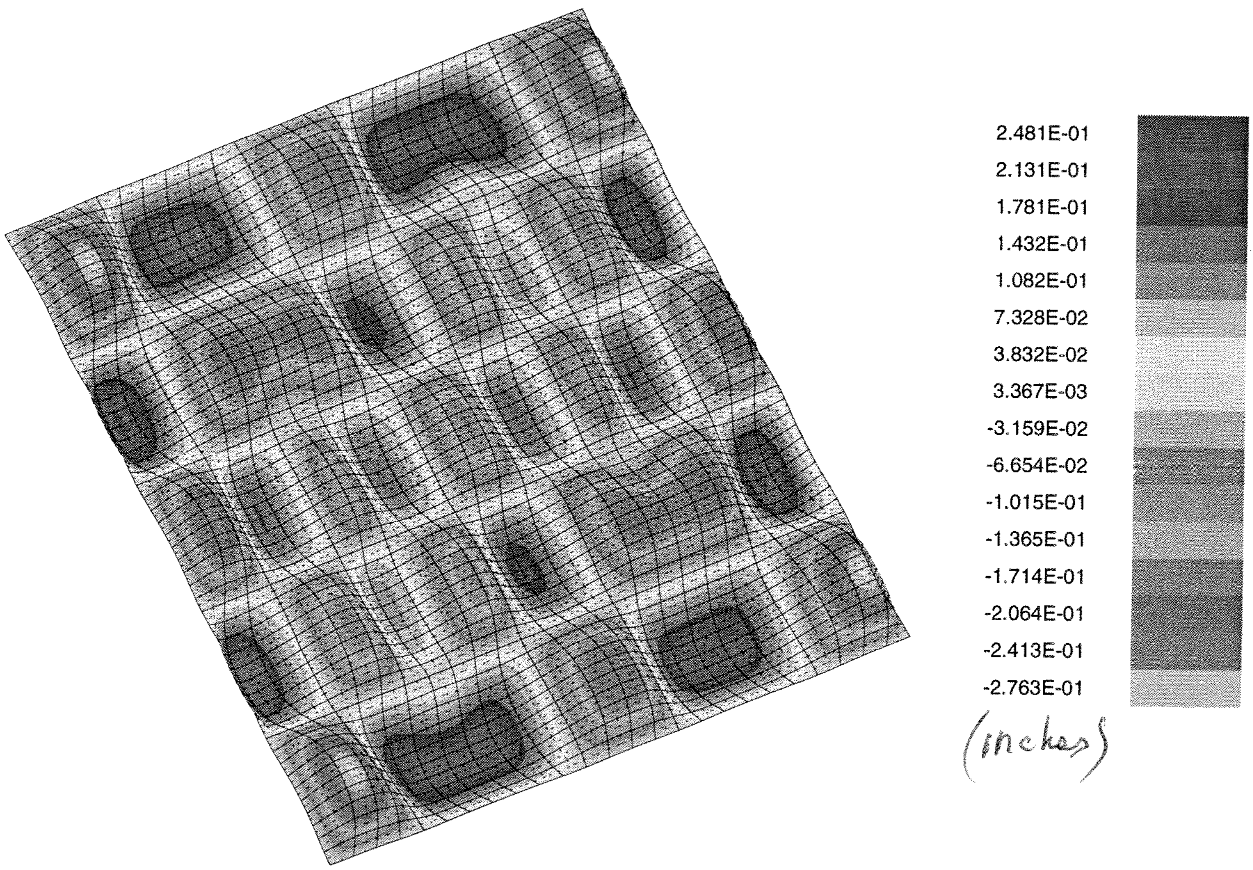
1.267E+01

y x z



Fig. 1.36

riks.postbuck.fakestiff.5bay.step167.pdf




solution scale = 0.1306E+02
PA= 7.05746E-01 PB= 0.00000E+00 PX= 0.00000E+00
step 167 displacement w contours
nonlinear w
Minimum value = -2.76273E-01, Maximum value = 2.48052E-01

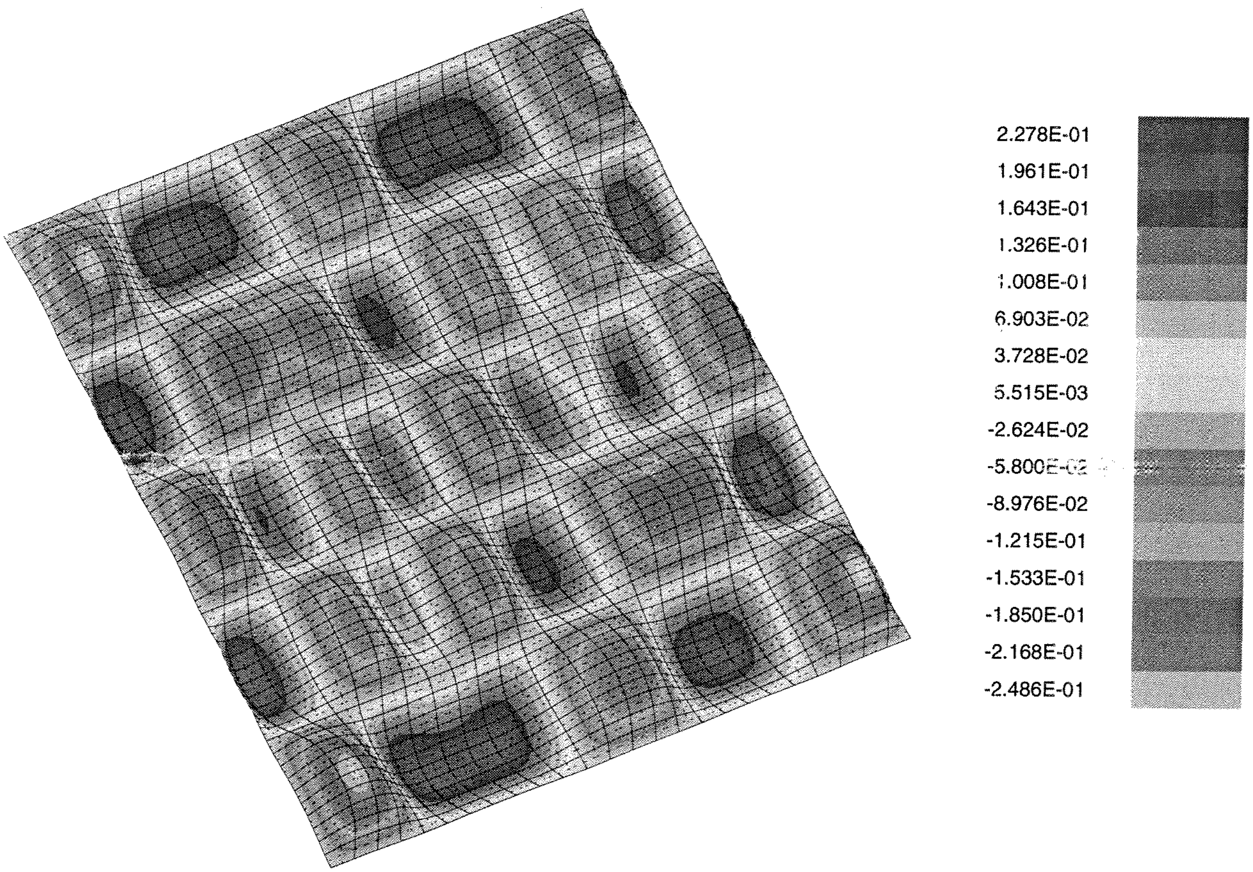
Θ x 24.00
Θ y -22.00
Θ z 30.00

1.267E+01

y
x
z

Fig. 1.37

riks.postbuck.fakestiff.5bay.step210.pdf




solution scale = 0.1454E+02
PA= 6.37447E-01 PB= 0.00000E+00 PX= 0.00000E+00
step 210 displacement w contours
nonlinear w
Minimum value = -2.48563E-01, Maximum value = 2.27834E-01

Θ x 24.00
Θ y -22.00
Θ z 30.00

1.267E+01

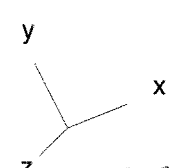



Fig. 1.38

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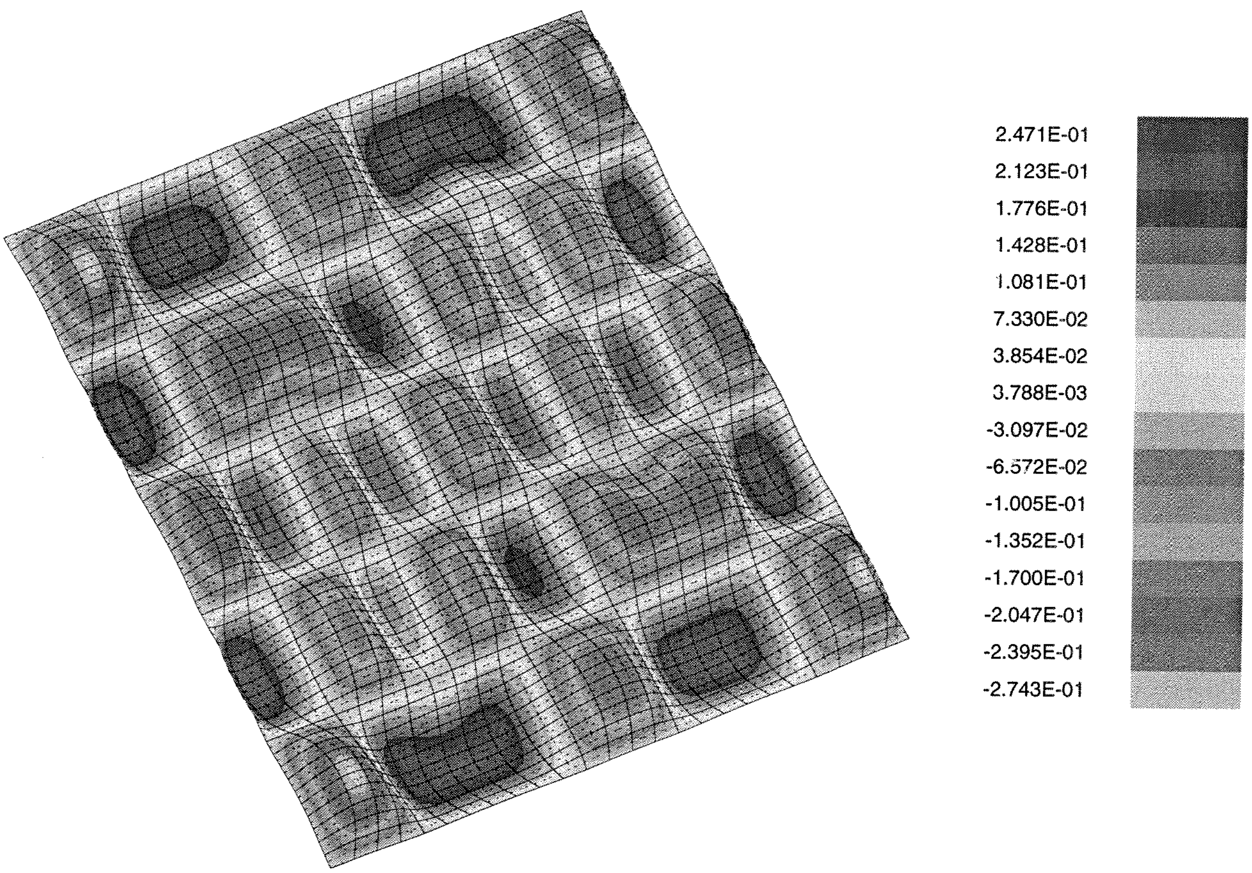
riks.postbuck.fakestiff.5bay.step261.pdf




solution scale = 0.1311E+02
PA= 7.00726E-01 PB= 0.00000E+00 PX= 0.00000E+00
step 261 displacement w contours
nonlinear w
Minimum value = -2.74257E-01, Maximum value = 2.47078E-01

Θ x 24.00
Θ y -22.00
Θ z 30.00

1.267E+01

y
x
z

87

Fig. 1.39

Flataxial.w.compare.1bay5bay.{input / ps}

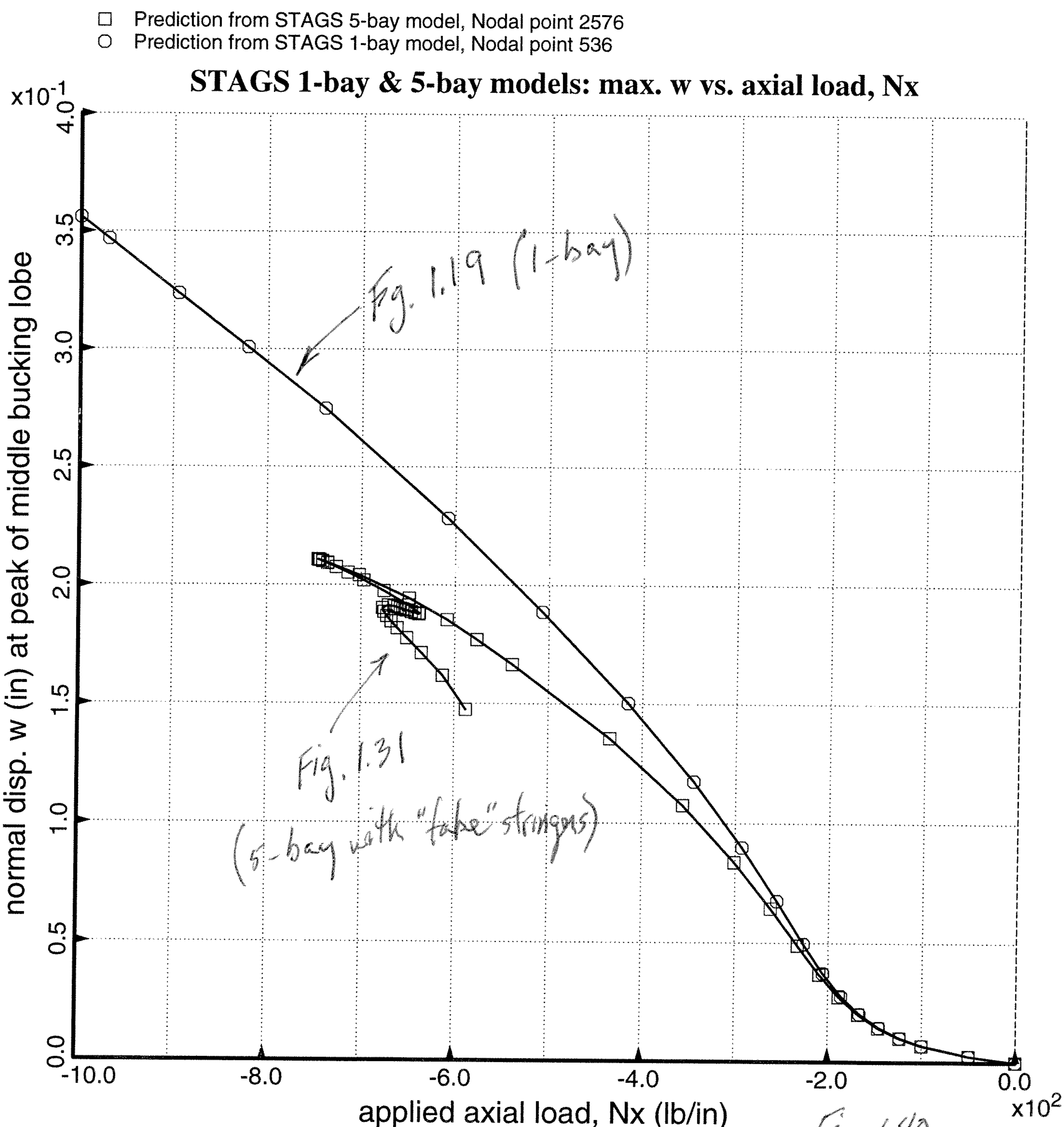



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Fig. 1.40

Sub-section 1.3

Flat <u>Stiffened</u> Plate

50 x 50 inches

$N_x = -1000$ lb/in

Table 1.27

Begin sub-section 1.3

riks.5bay.axial.stags.realstiff.runstream

30 June, 2008

Example 3.1

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.

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 for the optimum design).

3. 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.

4. Linear bifurcation buckling and nonlinear equilibrium STAGS runs are again executed, this time with a different boundary condition used along the two longitudinal (axially oriented) edges of the flat panel.

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. 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       (cp riks.realstiff.opt riks.OPT; input = riks.OPT = Table 1.30, ITYPE=1)
pandaopt        (optimize)
pandaopt        (optimize)
pandaopt        (optimize)  NOTE: You could have executed SUPEROPT here instead
pandaopt        (optimize)        of executing a sequence of PANDAOPTs. You might
pandaopt        (optimize)        well have come up with a different and lighter
pandaopt        (optimize)        optimum design. I always use SUPEROPT in "real" cases.
pandaopt        (optimize)
cp riks.OPP riks.realstiff.opp = Table 1.31
chooseplot      (cp riks.realstiff.cpl riks.CPL; input = riks.CPL = 1.31(b))
diplot
cp riks.3.ps riks.axial.realstiff.margins.ps = Fig. 1.41
cp riks.5.ps riks.axial.realstiff.objective.ps = Fig. 1.42
mainsetup       (change NPRINT to 2 and ITYPE to 2, analysis of fixed design) = Table 1.32
pandaopt        (analyze the fixed design, which is the optimum design.) (See Tables 1.33-1.45)
stagsunit       (cp riks.axial.realstiff.5bay.stg riks.STG; input = riks.STG) = Table 1.46
```

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

(Run STAGS, first to get linear buckling mode shown in Figs. 1.43 & 1.44, and next to get nonlinear behavior of imperfect shell shown in Figs. 1.45 - 1.47)

(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.)

(Perform another STAGS analysis with different boundary conditions along the two longitudinal (axially oriented) edges)

```
stagsunit       (input is riks.STG listed in Table 1.47. This riks.STG file
                 is valid for linear bifurcation buckling)
```

(Run STAGS to get linear buckling mode, shown in Fig. 1.48.)

```
stagsunit        (input is riks.STG listed in Table 1.48. 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. 1.49-1.51)

(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 1.50(a))
setup            (PANDA2 gets matrix templates.)
mainsetup        (Input = riks.OPT = Table 1.50(b))
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 1.51)
diplot           (generate postscript files, riks.3.ps, riks.4.ps, riks.5.ps,
                  and riks.7.ps. See Figs. 1.52, 1.53, 1.54, 1.55, respectively)
chooseplot       (user chooses more to plot vs applied load.
                  Input = riks.CPL = Table 1.52)
diplot           (generate postscript files, riks.8.ps, riks.9.ps, riks.10.ps.
                  See Figs. 1.56, 1.57, 1.58, respectively.)

(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 1.53. 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. 1.59 for the BIGBOSOR4 model and Fig. 1.60 for
                  the buckling mode.)
cleanup
```

Table 1.28 riks.BEG (riks.realstiff.beg)

Error! This should have been 60000!

```
       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.      $ 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?
  0.8704100E-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)
       n         $ Is the panel curved in the plane of the screen (Y for cyls.)?
       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.      $ 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))?
          0      $ Prebuckling phase: choose 0=simple support or 1=clamping
          0      $ Buckling: choose 0=simple support or 1=clamping
```

input for "BEGIN"

Table 1.29 riks.DEC (riks.radstiff.dec)

```
    n          $ Do you want a tutorial session and tutorial output?
    n          $ Want to use default for thickness decision variables (type H(elp)?
       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) ?
    n          $ Any 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?
```

stringer height

skin ~~stiffness~~ thickness

stringer thickness

input for "DECIDE"

Table 1.30 riks.OPT (riks.realstiff.opt)

```
          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)
          N          $ 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)
           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)
```

input for "MAINSETUP" & "PANDAOPT" for optimization

Table 1.31 riks.OPP = (2 pages) p.1 of 2

output from PANDAOPT for optimization

riks.realstiff.opp (abridged)

```
         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; 4)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
   2 2.9986E+01   NOT FEASIBLE  (0; 3)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
   3 3.2823E+01  MOSTLY UNFEASIB(0; 2)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
   4 3.4700E+01  MORE UNFEASIBLE(0; 2)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
   5 3.6121E+01  MILDLY UNFEASIB(0; 2)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
   6 3.7463E+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
 -------------------------------------------------------PANDAOPT
   7 3.7463E+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
   8 3.8252E+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
   9 3.8072E+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
  10 3.6525E+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
  11 3.5086E+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
  12 3.4086E+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
 -------------------------------------------------------PANDAOPT
  13 3.4086E+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 3.1141E+01  MORE UNFEASIBLE(0; 2)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
  15 3.3080E+01  MILDLY UNFEASIB(0; 2)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
  16 3.2803E+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
  17 3.1337E+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
  18 3.2986E+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
 -------------------------------------------------------PANDAOPT
  19 3.2986E+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
  20 2.9666E+01  MORE UNFEASIBLE(0; 2)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
  21 3.1667E+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
  22 2.9897E+01  MILDLY UNFEASIB(0; 2)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
 0
  23 3.1162E+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
  24 3.2801E+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
 -------------------------------------------------------PANDAOPT
  25 3.2801E+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
  26 3.0446E+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
  27 2.8233E+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
  28 2.7161E+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
  29 2.6491E+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
```

Table 1.31 (end) riks.OPP P. 2 of 2

```
 30 2.6092E+01  ALMOST FEASIBLE(0; 4)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0»
0
-------------------------------------------------------PANDAOPT
 31 2.6092E+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
 32 2.5518E+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
 33 2.5615E+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
 34 2.5641E+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
 35 2.5641E+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   35; OBJMN0,OBJPLT(ITRPLT)=  2.5518E+01  2.5641E+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   1.000E+01      B(STR):stiffener spacing, b: STR seg=NA, layer=NA
  2   STR   2     0   3.000E+00     B2(STR):width of stringer base, b2 (must be > 0, see Help)»
: STR seg=2 , lay
  3   STR   3     0   2.111E+00      H(STR):height of stiffener (type H for sketch), h: STR se»
g=3 , layer=NA
  4   SKN   1     1   6.418E-02   T(1 )(SKN):thickness for layer index no.(1 ): SKN seg=1 , lay»
er=1
  5   STR   3     1   1.813E-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   2.561E+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   1.000E+01      B(STR):stiffener spacing, b: STR seg=NA, layer=NA
  2   STR   2     0   3.000E+00     B2(STR):width of stringer base, b2 (must be > 0, see Help)»
: STR seg=2 , lay
  3   STR   3     0   2.097E+00      H(STR):height of stiffener (type H for sketch), h: STR se»
g=3 , layer=NA
  4   SKN   1     1   6.413E-02   T(1 )(SKN):thickness for layer index no.(1 ): SKN seg=1 , lay»
er=1
  5   STR   3     1   1.809E-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   2.552E+01  WEIGHT OF THE ENTIRE PANEL

 *************                        ************
 ******************* DESIGN OBJECTIVE ******************
```

optimum design used in STAGS runs.

Table 1.31(b)

riks.itype1.cpl (riks.CPL)

```
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,..)
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,..)
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 to CHOOSEPLOT

riks.3.ps (riks.margins.itype1.ps)
(riks.axial.realstiff.margins.ps)

output from
CHOOSEPLOT & DIPLOT

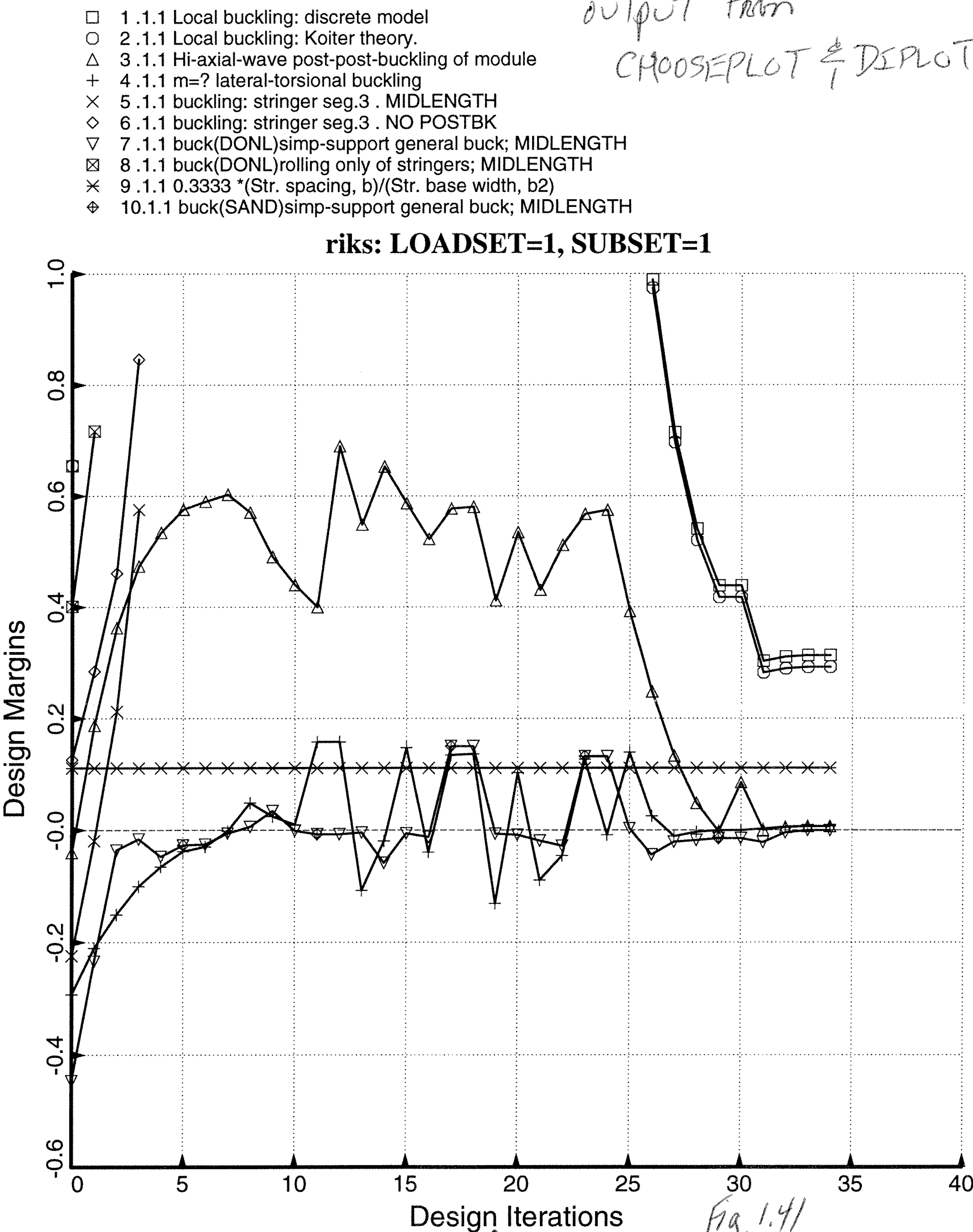


Fig. 1.41

(riks.objective.itype1.ps)
riks.5.ps (riks.axial.realstiff.objective.ps)
output from "CHOOSEPLOT" & "DIPLOT"

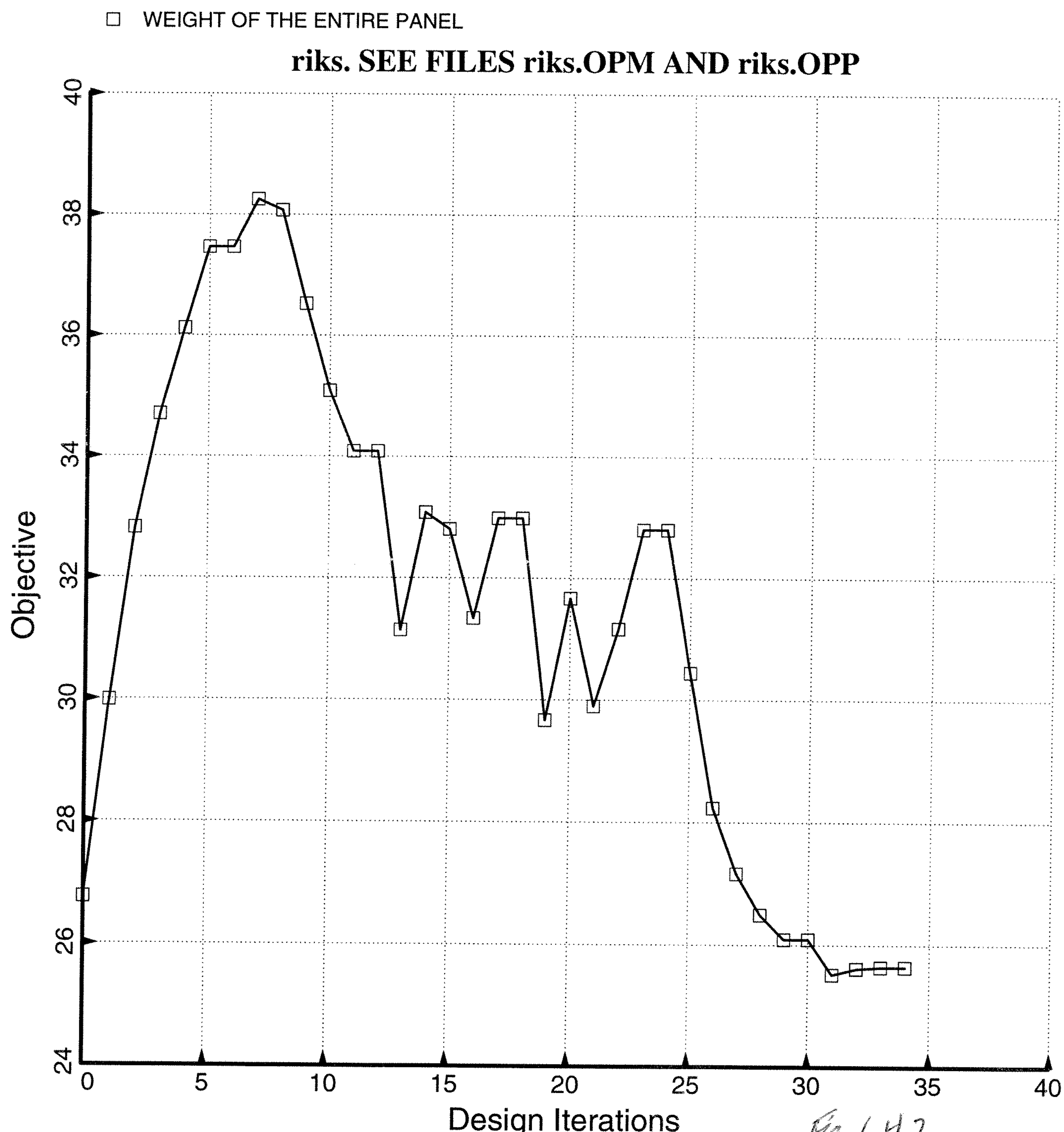


Fig. 1.42

Table 1.32 riks.OPT (for fixed design = optimum design)

```
        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)?
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" & "PANDAOPT"

1.33 — 1.45

Next several tables are from various ~~pa~~ sections (Chapters) of the riks.OPM file, which contains output from PANDAOPT for analysis of a fixed design (ITYPE = 2)