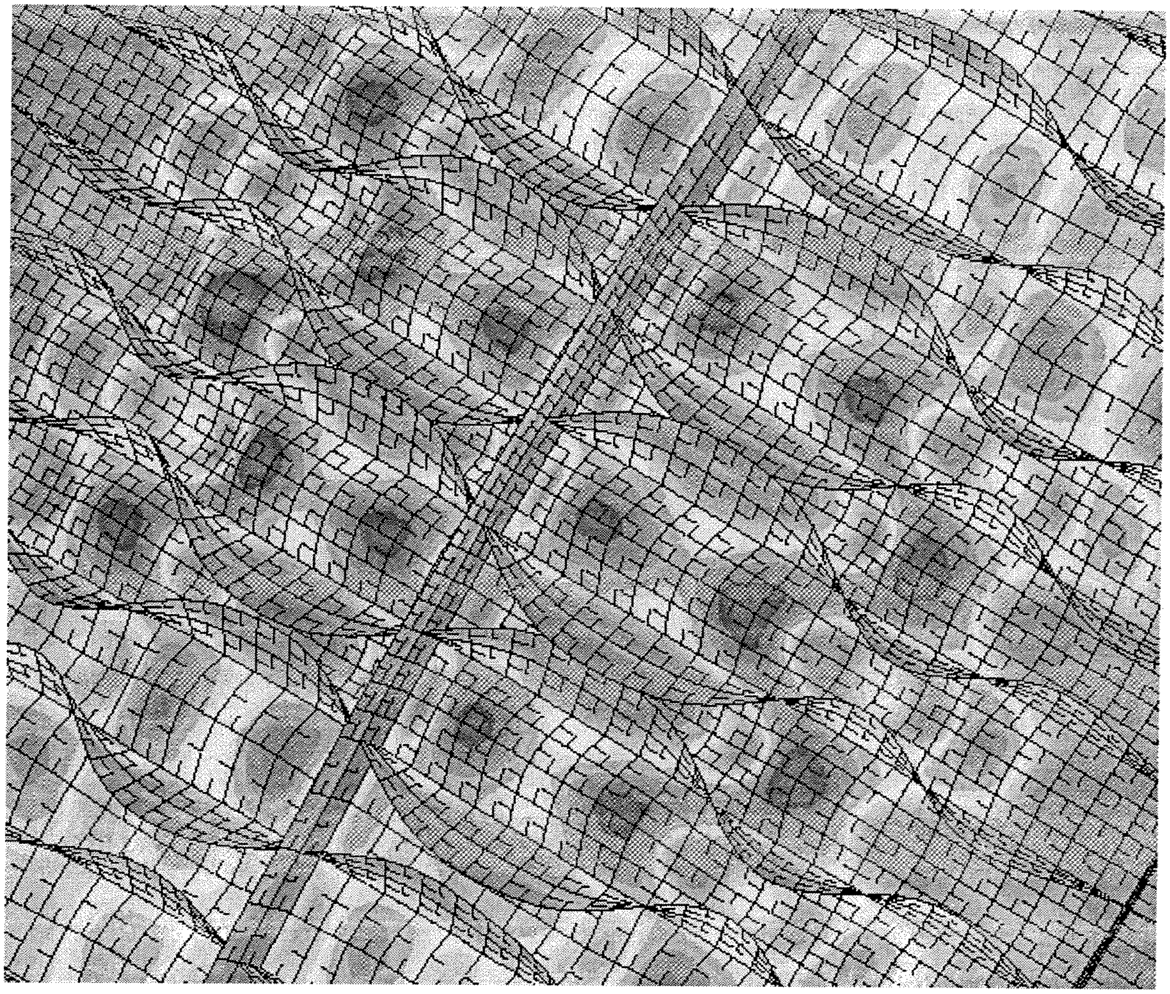


outer fiber effective stress
at PA= 1.275

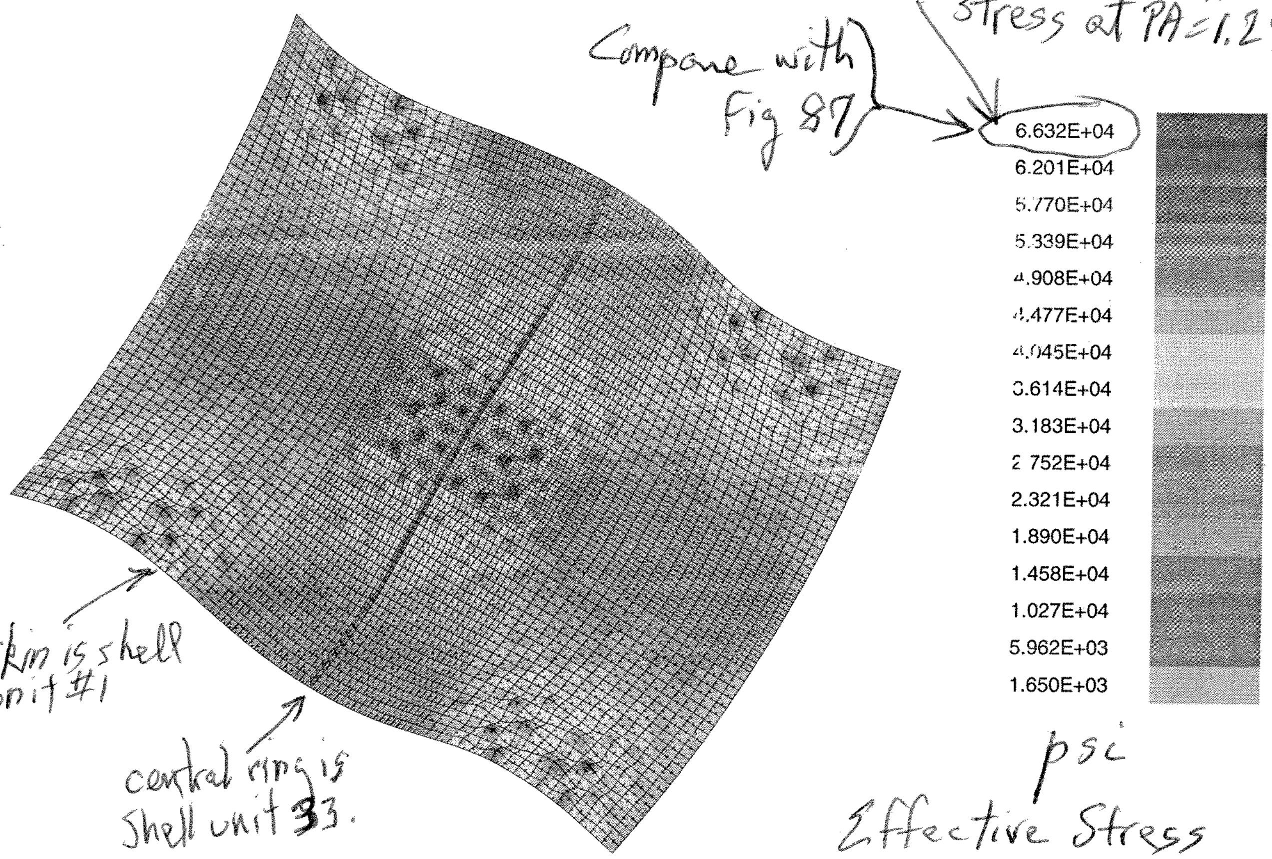
Fig. 84

Outer fiber $\bar{\sigma}$ at PA=1.275

Shell $\boxed{\text{skin}}$ $\bar{\sigma}$ at PA=1.275

maximum effective stress at PA=1.275

Compare with Fig 87



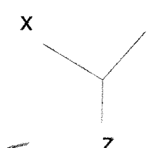
skin is shell unit #1

central ring is shell unit 33.

psi
Effective Stress

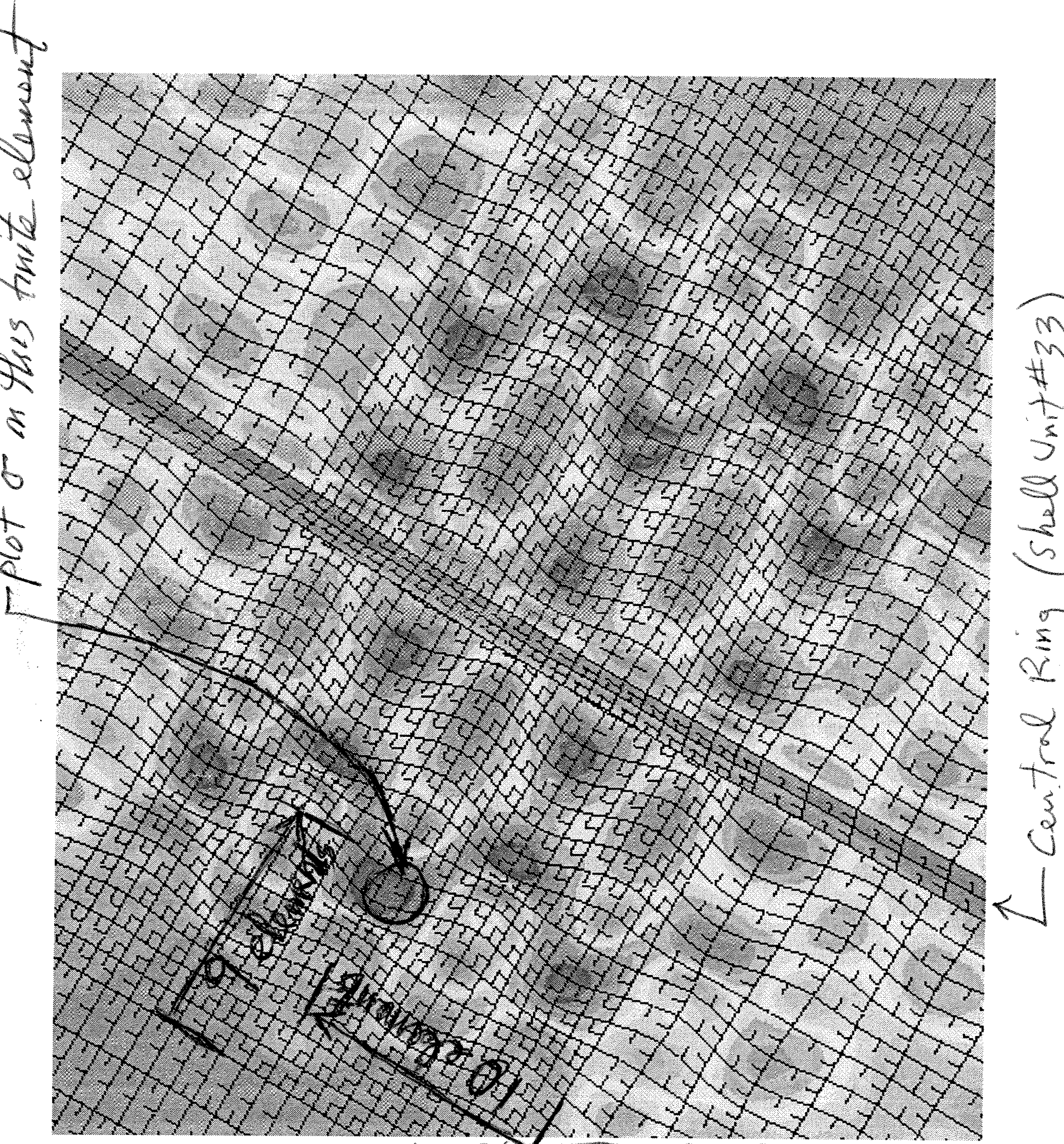
solution scale = 0.1652E+02
PA= 1.27518E+00 PB= 0.00000E+00 PX= 0.00000E+00
step 30 fabrication system seff, layer 1, outer fiber
nonlinear effective stress - outer fiber same view a linear buckling mode
Minimum value = 1.65031E+03, Maximum value = 6.63234E+04

Θ x -35.84
Θ y -179.86
Θ z 35.63



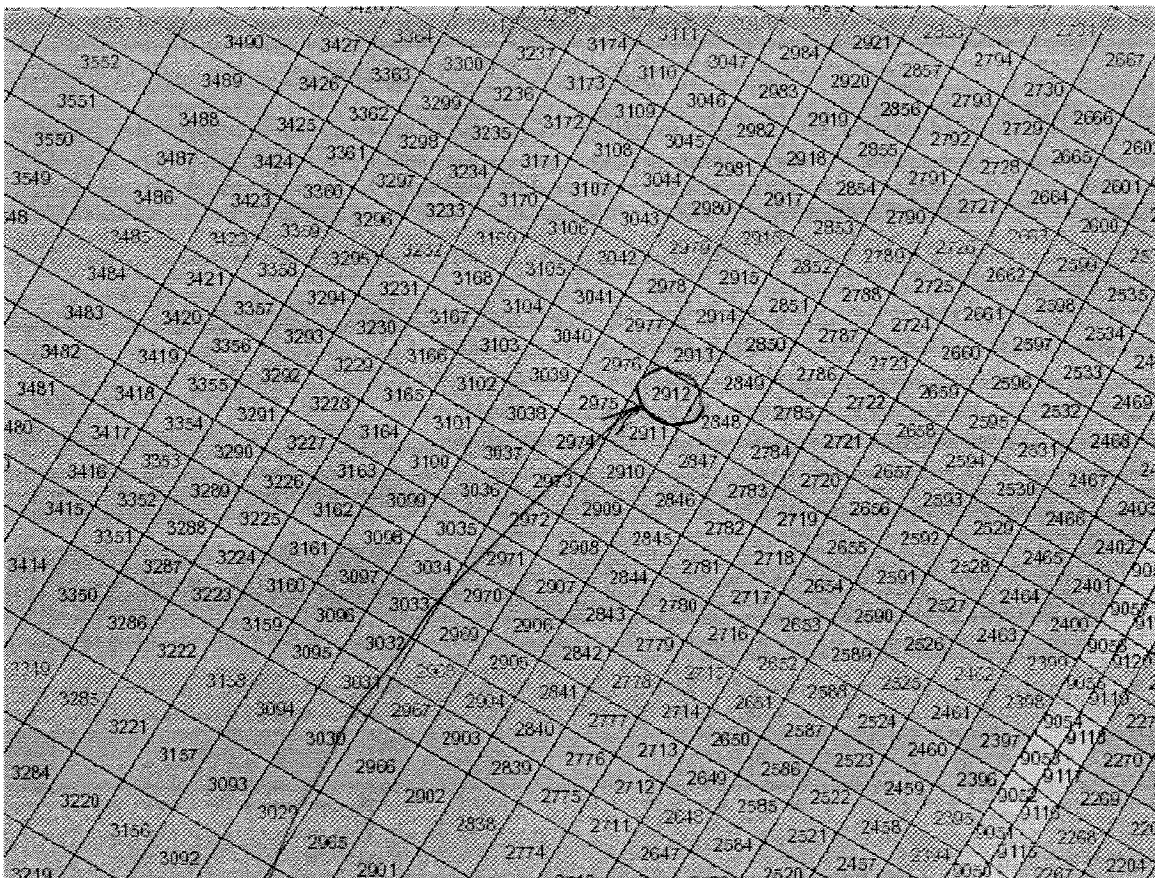
1.603E+01

Fig. 85(a)



outer fiber $\boxed{\text{skin}}$ effective stress at PA=1.275

Fig. 85(b)



Finite element numbers in $\boxed{\text{skin}}$

Fig. 87: $\vec{\sigma}$ at the integration points in Finite Element #2912 is plotted in Fig. 87.

Fig. 86

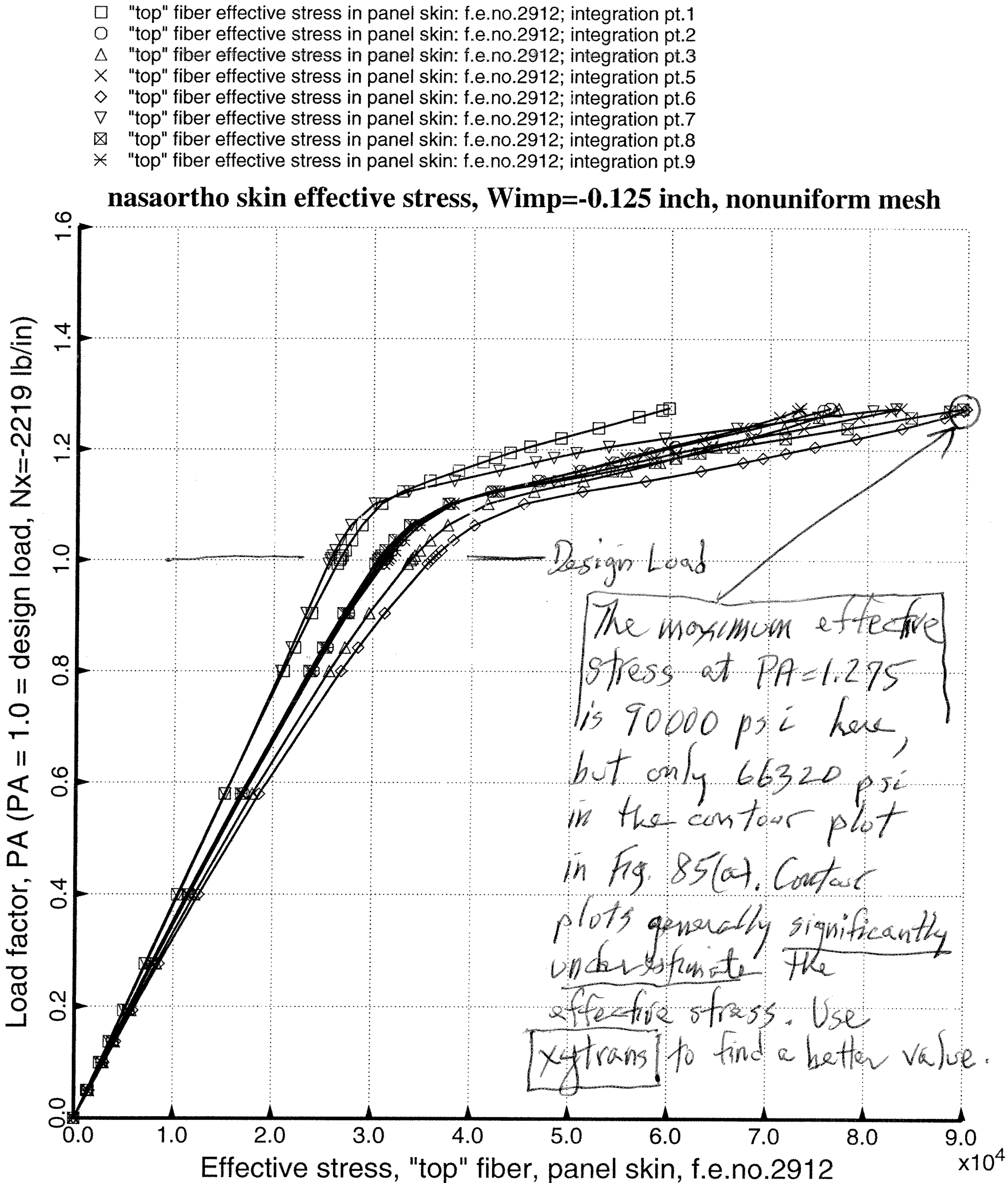

"top" fiber effective stress in panel skin: f.e.no.2912; integration pt.1
"top" fiber effective stress in panel skin: f.e.no.2912; integration pt.2
"top" fiber effective stress in panel skin: f.e.no.2912; integration pt.3
"top" fiber effective stress in panel skin: f.e.no.2912; integration pt.5
"top" fiber effective stress in panel skin: f.e.no.2912; integration pt.6
"top" fiber effective stress in panel skin: f.e.no.2912; integration pt.7
"top" fiber effective stress in panel skin: f.e.no.2912; integration pt.8
"top" fiber effective stress in panel skin: f.e.no.2912; integration pt.9
nasaortho skin effective stress, Wimp=-0.125 inch, nonuniform mesh
Load factor, PA (PA = 1.0 = design load, Nx=-2219 lb/in)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
x10^4
Effective stress, "top" fiber, panel skin, f.e.no.2912
Design Load
The maximum effective stress at PA=1.275 is 90000 psi here, but only 66320 psi in the contour plot in Fig. 85(a). Contour plots generally significantly underestimate the effective stress. Use xytrans to find a better value.

Fig. 87

Table 69 The effect of $\boxed{\text{ICONSV}}$ (2 pages)

nasaortho.iconsv.compare

COMPARE BUCKLING LOAD FACTORS FOR INTER-RING AND GENERAL BUCKLING WITH THE USE OF THE THREE POSSIBLE VALUES OF THE "CONSERVATIVENESS" INDEX, ICONSV = 1, 0, -1, Wimp=0.0

"STAGS worthy" design listed in Table 33b Wimp=0.0

```
=====================================================================
ICONSV = 1   <- recommended value

inter-ring buckling:
 Buckling load factor from SUB. LOCAL, EIGITR(16)=  2.5429E+00
 knockdown for smeared stringers from SUB.EIGMOD,
                                               SMRFAC=  8.2685E-01
 knockdown for transverse shear deformation (t.s.d.) from SUB.SHRRED,
                                               SHRFAC=  9.6771E-01
 Buckling load factor BEFORE knockdown for smeared stringers=  2.5429E+00
 Buckling load factor AFTER  knockdown for smeared stringers=  2.1026E+00
 NOTE: The buckling load factor,  2.1026E+00, has not yet been
 further reduced by the "shear/anisotropy" factor, FKNSRG(1)=  1.0000E+00
 Ratio (AFTER/BEFORE) knockdown for smeared stringers=   8.268E-01
 Knockdown factors, EIGKNS(1),FKNSRG(1),FKNOCK(8)=  8.2685E-01  1.0000E+00  9.6793E-01
 Margin= 1.0372E+00 Inter-ring bucklng, discrete model, n=17  circ.halfwaves;FS=0.999
---------------------------------------------------------------------
```

Compare with STAGS, Fig. 20

```
general buckling
 EIGMNC=  2.62E+00  2.62E+00  2.62E+00  1.00E+17  1.00E+17  2.62E+00  6.21E+00
 SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
 MWAVEX=    3         3         3         0         0         3         4
 NWAVEX=    6         6         6         0         0         6         0

 Buckling load factor before t.s.d.=  2.6233E+00 After t.s.d.=  2.4813E+00
 Buckling load factor BEFORE knockdown for smeared stringers=  2.4813E+00
 Buckling load factor AFTER  knockdown for smeared stringers=  2.3269E+00
 General buckling load factor before and after knockdown:
 EIGGEN(before modification by 5 factors below)      =  2.3269E+00
 Knockdown factor from modal imperfection(s)         =  1.0000E+00
 Knockdown factor for smearing rings on cyl. shell   =  9.4809E-01
 Knockup factor to avoid twice accounting for t.s.d.=  1.0000E+00
 1st modifying factor, FKNMOD=1 or 1/(EIG9X*FMDKD9) =  1.0000E+00
 2nd modifying factor, EIGMR9=1 or EIGGNX/EIGGEN    =  1.0000E+00
 After knockdn,EIGGEN*FKNOCK(9)*(RNGKNK/SHRFCT)*FKNMOD*EIGMR9=  2.2061E+00
     13      2.20613E+00   buckling load factor simp-support general buck;M=3;N=6;slope=0.
 Margin= 1.2083E+00 buck.(SAND);simp-support general buck;M=3;N=6;slope=0.;FS=0.999
---------------------------------------------------------------------
```

Compare (STAGS Fig 18) & Fig 46

```
ICONSV = 0

inter-ring buckling:
 Buckling load factor from SUB. LOCAL, EIGITR(16)=  2.5413E+00
 knockdown for smeared stringers from SUB.EIGMOD,
                                               SMRFAC=  1.0000E+00
 knockdown for transverse shear deformation (t.s.d.) from SUB.SHRRED,
                                               SHRFAC=  9.6773E-01
 Buckling load factor BEFORE knockdown for smeared stringers=  2.5413E+00
 Buckling load factor AFTER  knockdown for smeared stringers=  2.5413E+00
 NOTE: The buckling load factor,  2.5413E+00, has not yet been
 further reduced by the "shear/anisotropy" factor, FKNSRG(1)=  1.0000E+00
 Ratio (AFTER/BEFORE) knockdown for smeared stringers=   1.000E+00
 Knockdown factors, EIGKNS(1),FKNSRG(1),FKNOCK(8)=  1.0000E+00  1.0000E+00  1.0000E+00
 Margin= 1.5438E+00 Inter-ring bucklng, discrete model, n=18  circ.halfwaves;FS=0.999
---------------------------------------------------------------------
```

Compare with STAGS, Fig 20

```
general buckling
 EIGMNC=  2.62E+00  2.62E+00  2.62E+00  1.00E+17  1.00E+17  2.62E+00  6.21E+00
 SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
 MWAVEX=    3         3         3         0         0         3         4
 NWAVEX=    6         6         6         0         0         6         0

 Buckling load factor before t.s.d.=  2.6233E+00 After t.s.d.=  2.4813E+00
 Buckling load factor BEFORE knockdown for smeared stringers=  2.4813E+00
 Buckling load factor AFTER  knockdown for smeared stringers=  2.4813E+00
 General buckling load factor before and after knockdown:
 EIGGEN(before modification by 5 factors below)      =  2.4813E+00
 Knockdown factor from modal imperfection(s)         =  1.0000E+00
 Knockdown factor for smearing rings on cyl. shell   =  9.4809E-01
 Knockup factor to avoid twice accounting for t.s.d.=  1.0000E+00
 1st modifying factor, FKNMOD=1 or 1/(EIG9X*FMDKD9) =  1.0000E+00
 2nd modifying factor, EIGMR9=1 or EIGGNX/EIGGEN    =  1.0000E+00
```

Compare with STAGS, Figs 18, 46

This output is available in the *.OPM file if NPRINT = 2 in the *.OPT file

Table 69 (p. 2 of 2)

```
 After knockdn,EIGGEN*FKNOCK(9)*(RNGKNK/SHRFCT)*FKNMOD*EIGMR9=  2.3525E+00
     11        2.35246E+00   buckling load factor simp-support general buck;M=3;N=6;slope=0.
 Margin= 1.3548E+00 buck.(SAND);simp-support general buck;M=3;N=6;slope=0.;FS=0.999
---------------------------------------------------------------------------------------

ICONSV = -1

general buckling
 EIGMNC=  2.62E+00  2.62E+00  2.62E+00  1.00E+17  1.00E+17  2.62E+00  6.21E+00
 SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
 MWAVEX=    3         3         3         0         0         3         4
 NWAVEX=    6         6         6         0         0         6         0

 Buckling load factor before t.s.d.=  2.6233E+00 After t.s.d.=  2.4813E+00
 Buckling load factor BEFORE knockdown for smeared stringers=  2.4813E+00
 Buckling load factor AFTER  knockdown for smeared stringers=  2.4813E+00
 General buckling load factor before and after knockdown:
 EIGGEN(before modification by 5 factors below)     =  2.4813E+00
 Knockdown factor from modal imperfection(s)        =  1.0000E+00
 Knockdown factor for smearing rings on cyl. shell  =  1.0000E+00
 Knockup factor to avoid twice accounting for t.s.d.=  1.0000E+00
 1st modifying factor, FKNMOD=1 or 1/(EIG9X*FMDKD9) =  1.0000E+00
 2nd modifying factor, EIGMR9=1 or EIGGNX/EIGGEN    =  1.0000E+00
 After knockdn,EIGGEN*FKNOCK(9)*(RNGKNK/SHRFCT)*FKNMOD*EIGMR9=  2.4813E+00
     11        2.48126E+00   buckling load factor simp-support general buck;M=3;N=6;slope=0.
 Margin= 1.4837E+00 buck.(SAND);simp-support general buck;M=3;N=6;slope=0.;FS=0.999
=====================================================================================
```

Compare with STAGS, Figs. 18, 46

Output listed in nasacotho.OPM
if NPRINT=2 in the nasacotho.OPT file.

Table 70 The effect of $\boxed{\text{ICONSV}}$ (2 pages)

"STAGSworthy" design listed in Table 33a, "Winept0.125"

```
nasaortho.iconsv.compare.margins

COMPARE PANDA2 MARGINS (ESPECIALLY THE STRESS MARGINS)
WITH THE USE OF THE THREE POSSIBLE VALUES OF THE
"CONSERVATIVENESS" INDEX, ICONSV = 1, 0, -1
==========================================================================
ICONSV = 1

 MARGINS FOR CURRENT DESIGN: LOAD CASE NO. 1, SUBCASE NO. 1
 MAR. MARGIN
 NO.  VALUE                DEFINITION
  1  4.98E-02 Local buckling from discrete model-1.,M=4   axial halfwaves;FS=0.99
  2  4.47E-02 Bending-torsion buckling; M=4  ;FS=0.999
  3  3.87E-02 Bending-torsion buckling: Koiter theory,M=4   axial halfwav;FS=0.99
  4  2.54E+00 eff.stress:matl=1,SKN,Dseg=2,node=6,layer=1,z=-0.0248; MID.;FS=1.
  5  7.69E+06 stringer popoff margin:(allowable/actual)-1, web 1  MID.;FS=1.
  6  2.73E-01 eff.stress:matl=2,STR,Dseg=3,node=11,layer=1,z=0.0403; MID.;FS=1.
  7  1.76E-01 (m=4   lateral-torsional buckling load factor)/(FS)-1;FS=0.999
  8  1.63E-01 Ring sidesway buk., discrete model, n=49  circ.halfwaves;FS=0.999
  9  1.14E+00 eff.stress:matl=1,SKN,Iseg=1,at:n=1,layer=1,z=-0.0248;-MID.;FS=1.
 10  2.87E-01 eff.stress:matl=2,STR,Iseg=3,at:TIP,layer=1,z=0.;-MID.;FS=1.
 11  4.40E-01 eff.stress:matl=3,RNG,Iseg=3,at:TIP,layer=1,z=0.;-MID.;FS=1.
 12  1.45E-02 buckling margin stringer Iseg.3 . Local halfwaves=5  .MID.;FS=1.
 13 -8.20E-03 buckling margin stringer Iseg.3 . Local halfwaves=5  .NOPO;FS=1.
 14  5.21E-01 buck.(SAND);simp-support general buck;M=3;N=6;slope=0.;FS=0.999
 15  1.61E+01 buck.(SAND);rolling with smear rings; M=172;N=1;slope=0.;FS=0.999
 16  6.79E-01 buck.(SAND);rolling only of stringers;M=45;N=0;slope=0.;FS=1.4
 17  1.53E+01 buck.(SAND);rolling only axisym.rings;M=0;N=0;slope=0.;FS=1.4
 18  6.27E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
------------------------------------------------------------------------------

ICONSV = 0

 MARGINS FOR CURRENT DESIGN: LOAD CASE NO. 1, SUBCASE NO. 1
 MAR. MARGIN
 NO.  VALUE                DEFINITION
  1  8.98E-02 Local buckling from discrete model-1.,M=4   axial halfwaves;FS=0.99
  2  8.50E-02 Bending-torsion buckling; M=4  ;FS=0.999
  3  7.86E-02 Bending-torsion buckling: Koiter theory,M=4   axial halfwav;FS=0.99
  4  2.42E+00 eff.stress:matl=1,SKN,Dseg=2,node=6,layer=1,z=-0.0248; MID.;FS=1.
  5  3.73E-01 eff.stress:matl=2,STR,Dseg=3,node=11,layer=1,z=0.0403; MID.;FS=1.
  6  2.18E-01 (m=4   lateral-torsional buckling load factor)/(FS)-1;FS=0.999
  7  3.70E-01 Ring sidesway buk., discrete model, n=51  circ.halfwaves;FS=0.999
  8  3.70E-01 Lo-n Ring sidesway, discrete model, n=48  circ.halfwaves;FS=0.999
  9  1.23E+00 eff.stress:matl=1,SKN,Iseg=1,at:n=1,layer=1,z=-0.0248;-MID.;FS=1.
 10  3.87E-01 eff.stress:matl=2,STR,Iseg=3,at:TIP,layer=1,z=0.;-MID.;FS=1.
 11  5.93E-01 eff.stress:matl=3,RNG,Iseg=3,at:TIP,layer=1,z=0.;-MID.;FS=1.
 12  6.83E-01 buck.(SAND);simp-support general buck;M=3;N=6;slope=0.;FS=0.999
 13  1.60E+01 buck.(SAND);rolling with smear rings; M=172;N=1;slope=0.;FS=0.999
 14  1.78E+01 buck.(SAND);rolling only axisym.rings;M=0;N=0;slope=0.;FS=1.4
 15  5.93E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
------------------------------------------------------------------------------

ICONSV = -1

 MARGINS FOR CURRENT DESIGN: LOAD CASE NO. 1, SUBCASE NO. 1
 MAR. MARGIN
 NO.  VALUE                DEFINITION
  1  1.73E-01 Local buckling from discrete model-1.,M=4   axial halfwaves;FS=0.99
  2  1.69E-01 Bending-torsion buckling; M=4  ;FS=0.999
  3  1.70E-01 Bending-torsion buckling: Koiter theory,M=4   axial halfwav;FS=0.99
  4  2.22E+00 eff.stress:matl=1,SKN,Dseg=2,node=6,layer=1,z=-0.0248; MID.;FS=1.
  5  6.44E-01 eff.stress:matl=2,STR,Dseg=3,node=11,layer=1,z=0.0403; MID.;FS=1.
  6  2.92E-01 (m=4   lateral-torsional buckling load factor)/(FS)-1;FS=0.999
  7  1.29E+00 Ring sidesway buk., discrete model, n=48  circ.halfwaves;FS=0.999
  8  1.49E+00 Lo-n Inter-ring buck.,discrete model,n=19  circ.halfwaves;FS=0.999
  9  1.42E+00 eff.stress:matl=1,SKN,Iseg=1,at:n=1,layer=1,z=-0.0248;-MID.;FS=1.
 10  6.57E-01 eff.stress:matl=2,STR,Iseg=3,at:TIP,layer=1,z=0.;-MID.;FS=1.
 11  1.24E+00 eff.stress:matl=3,RNG,Iseg=3,at:TIP,layer=1,z=0.;-MID.;FS=1.
 12  7.76E-01 buck.(SAND);simp-support general buck;M=3;N=6;slope=0.;FS=0.999
 13  1.60E+01 buck.(SAND);rolling with smear rings; M=172;N=1;slope=0.;FS=0.999
 14  3.19E+01 buck.(SAND);rolling only axisym.rings;M=0;N=0;slope=0.;FS=1.4
 15  5.33E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
------------------------------------------------------------------------------

Note especially the most critical stress margin for ICONSV = 1, 0, -1::
```

Table 70 (p. 2 of 2)

```
ICONSV = 1
 6  2.73E-01 eff.stress:matl=2,STR,Dseg=3,node=11,layer=1,z=0.0403; MID.;FS=1.

ICONSV = 0
 5  3.73E-01 eff.stress:matl=2,STR,Dseg=3,node=11,layer=1,z=0.0403; MID.;FS=1.

ICONSV = -1
 5  6.44E-01 eff.stress:matl=2,STR,Dseg=3,node=11,layer=1,z=0.0403; MID.;FS=1.
==========================================================================
```

PART 3

Optimize the shell for the acreage remote from the weld lands.

(Wimp = ± 0.05")

Table 71 (2 pp.) nasaortho2.BEG

```
    n         $ Do you want a tutorial session and tutorial output?
 68.75000     $ Panel length normal to the plane of the screen, L1
 150.7960     $ Panel length in the plane of the screen, L2
    r         $ Identify type of stiffener along L1 (N,T,J,Z,R,A,C,G)
 4.000000     $ stiffener spacing, b
    1.333     $ width of stringer base, b2 (must be > 0, see Help)
    0.3       $ 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?
 0.1000000    $ 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)
      1       $ choose external (0) or internal (1) stringers
    r         $ Identify type of stiffener along L2  (N, T, J, Z, R, A)
 11.77200     $ stiffener spacing, b
      0       $ width of ring base, b2 (zero is allowed)
 0.3000000    $ height of stiffener (type H for sketch), h
    n         $ Are the rings cocured with the skin?
    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?
      3       $ layer index (1,2,...), for layer no.( 1)
    y         $ Is this a new layer type?
 0.1000000    $ thickness for layer index no.( 3)
      0       $ winding angle (deg.) for layer index no.( 3)
      3       $ material index (1,2,...) for layer index no.( 3)
    n         $ Any more layers or groups of layers in Segment no.( 3)
      1       $ choose external (0) or internal (1) rings
    y         $ Is the panel curved in the plane of the screen (Y for cyls.)?
 48.00000     $ 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)?
0.1100000E+08 $ Young's modulus,                E( 1)
0.3000000     $ Poisson's ratio,               NU( 1)
 4230769      $ 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 ?
 70000.00     $ Maximum allowable effective stress in material type( 1)
    n         $ Do you want to take advantage of "bending overshoot"?
0.9500000E-01 $ 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)?
0.1100000E+08 $ Young's modulus,                E( 2)
0.3000000     $ Poisson's ratio,               NU( 2)
 4230769.     $ 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 ?
 70000.00     $ Maximum allowable effective stress in material type( 2)
    n         $ Do you want to take advantage of "bending overshoot"?
0.9500000E-01 $ weight density (greater than 0!) of material type( 2)
    n         $ Is lamina cracking permitted along fibers (type H(elp))?
    y         $ Is this material isotropic (Y or N)?
0.1100000E+08 $ Young's modulus,                E( 3)
```

From Table 19

Table 71 (p. 2 of 2)

```
0.3000000      $ Poisson's ratio,                  NU( 3)
 4230769.      $ transverse shear modulus,        G13( 3)
       0       $ Thermal expansion coeff.,     ALPHA( 3)
       0       $ residual stress temperature (positive),TEMPTUR( 3)
   n           $ Want to supply a stress-strain "curve" for this mat'l? (N)
 y             $ Want to specify  maximum effective stress ?
 70000.00      $ Maximum allowable effective stress in material type( 3)
   n           $ Do you want to take advantage of "bending overshoot"?
0.9500000E-01  $ weight density (greater than 0!) of material type( 3)
   n           $ Is lamina cracking permitted along fibers (type H(elp))?
       0       $ Prebuckling: choose 0=bending included; 2=use membrane theory
       1       $ Buckling: choose 0=simple support or 1=clamping
```

Input for BEGIN

Table 72 nasaortho2.DEC

```
    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,...)
 1.000000      $ 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,...)
0.1000000E-01  $ Lower bound of variable no.( 3)
 2.000000      $ 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)
    y          $ Any more decision variables (Y or N) ?
       8       $ Choose a decision variable (1,2,3,...)
0.1000000E-01  $ Lower bound of variable no.( 8)
 2.000000      $ Upper bound of variable no.( 8)
    y          $ Any more decision variables (Y or N) ?
       9       $ Choose a decision variable (1,2,3,...)
0.1000000E-01  $ Lower bound of variable no.( 9)
 1.000000      $ Upper bound of variable no.( 9)
    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?
```

Input for DECIDE

B(RNG) is <u>not</u> a decision variable.

Table 73 nasaortho2.OPT (2 pages)

```
     n           $ Do you want a tutorial session and tutorial output?
 -2219.000       $ 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         $ Applied axial moment resultant (e.g. in-lb/in), Mx( 1)
       0         $ 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?
 0.9990000       $ Factor of safety for general instability, FSGEN( 1)
 0.9990000       $ Factor of safety for panel (between rings) instability, FSPAN( 1)
 0.9990000       $ Minimum load factor for local buckling (Type H for HELP), FSLOC( 1)
  1.000000       $ Minimum load factor for stiffener buckling (Type H), FSBSTR( 1)
  1.000000       $ Factor of safety for stress, FSSTR( 1)
     y           $ Do you want "flat skin" discretized module for local buckling?
     n           $ Do you want wide-column buckling to constrain the design?
  0.000000       $ Resultant (e.g. lb/in) normal to the plane of screen, Nx0( 1)
  0.000000       $ Resultant (e.g. lb/in) in the plane of the screen,    Ny0( 1)
       0         $ Axial load applied along the (0=neutral plane), (1=panel skin)
  0.000000       $ Uniform applied pressure [positive upward. See H(elp)], p( 1)
  0.000000       $ Out-of-roundness, Wimpg1=(Max.diameter-Min.diam)/4, Wimpg1( 1)
note →  0.05000  $ Initial buckling modal general imperfection amplitude, Wimpg2( 1)
  0.000000       $ Initial buckling modal inter-ring imperfection amplitude,Wpan( 1)
 0.1000000E-06   $ Initial local imperfection amplitude (must be positive), Wloc( 1)
     n           $ Do you want PANDA2 to change imperfection amplitudes (see H(elp))?( 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")?
     y           $ Want to provide another load set ?
 -2219.000       $ 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         $ Applied axial moment resultant (e.g. in-lb/in), Mx( 1)
       0         $ 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?
 0.9990000       $ Factor of safety for general instability, FSGEN( 1)
 0.9990000       $ Factor of safety for panel (between rings) instability, FSPAN( 1)
 0.9990000       $ Minimum load factor for local buckling (Type H for HELP), FSLOC( 1)
  1.000000       $ Minimum load factor for stiffener buckling (Type H), FSBSTR( 1)
  1.000000       $ Factor of safety for stress, FSSTR( 1)
     y           $ Do you want "flat skin" discretized module for local buckling?
     n           $ Do you want wide-column buckling to constrain the design?
  0.000000       $ Resultant (e.g. lb/in) normal to the plane of screen, Nx0( 1)
  0.000000       $ Resultant (e.g. lb/in) in the plane of the screen,    Ny0( 1)
       0         $ Axial load applied along the (0=neutral plane), (1=panel skin)
  0.000000       $ Uniform applied pressure [positive upward. See H(elp)], p( 1)
  0.000000       $ Out-of-roundness, Wimpg1=(Max.diameter-Min.diam)/4, Wimpg1( 1)
note → -0.05000  $ Initial buckling modal general imperfection amplitude, Wimpg2( 1)
  0.000000       $ Initial buckling modal inter-ring imperfection amplitude,Wpan( 1)
 0.1000000E-06   $ Initial local imperfection amplitude (must be positive), Wloc( 1)
     n           $ Do you want PANDA2 to change imperfection amplitudes (see H(elp))?( 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           $ 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]?
       1         $ 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)
```

Table 73 (p. 2 of 2)

```
    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

Table 74 (2 pages) nasaortho2.OPP (abridged)

nasaortho2.OPP after 3 executions of pandaopt (abridged)

```
       SUMMARY OF STATE OF THE DESIGN WITH EACH ITERATION
=================================================================================================
ITERA   WEIGHT                     FOR EACH LOAD SET....             ANY ABRUPT CHANGES IN MODE?
TION     OF                   (IQUICK; NO. OF CRITICAL MARGINS)      SLOPE CHANGE? (m,n) CHANGE?
NO.     PANEL     LOAD SET NO.-> 1       2       3       4       5     EIG. RATIOS    EIG. RATIOS
                                                    LOAD SET NO.->  1   2   3      1   2   3
                                                     SUBCASE NO.->  1 2 1 2 1 2    1 2 1 2 1 2
                                                         See Items 525 and 596 in panda2.news
-------------------------------------------------------------------------------------------------
-------------------------------------------------------PANDAOPT-----------------------------------
  1 9.9826E+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
  2 8.7422E+01  ALMOST FEASIBLE(0; 5)  (0; 8)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
  3 8.7024E+01      FEASIBLE    (0; 2)  (0; 6)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
  4 8.6974E+01      FEASIBLE    (0; 2)  (0; 6)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
  5 8.6925E+01      FEASIBLE    (0; 2)  (0; 6)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
  6 8.6223E+01      FEASIBLE    (0; 0)  (0; 6)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
-------------------------------------------------------PANDAOPT
  7 8.6223E+01      FEASIBLE    (0; 0)  (0; 6)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
  8 8.4465E+01  MORE UNFEASIBLE(0; 6)  (0;10)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
  9 8.5532E+01  ALMOST FEASIBLE(0; 2)  (0; 7)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 10 8.5132E+01      FEASIBLE    (0; 5)  (0; 6)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 11 8.4617E+01      FEASIBLE    (0; 7)  (0; 7)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 12 8.4335E+01  MILDLY UNFEASIB(0; 7)  (0;10)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
-------------------------------------------------------PANDAOPT
 13 8.4335E+01  MILDLY UNFEASIB(0; 7)  (0;10)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 14 8.5261E+01      FEASIBLE    (0; 2)  (0; 3)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 15 8.4237E+01  MILDLY UNFEASIB(0; 8)  (0;10)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 16 8.4483E+01  ALMOST FEASIBLE(0; 7)  (0; 8)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 17 8.4600E+01  ALMOST FEASIBLE(0; 6)  (0; 8)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 18 8.4504E+01  ALMOST FEASIBLE(0; 6)  (0; 9)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0

IOBJAL,ITRPLT=    0   18; OBJMN0,OBJPLT(ITRPLT)=  8.4237E+01  8.4504E+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    1.802E+00       B(STR):stiffener spacing, b: STR seg=NA, layer=NA
 2   STR   2     0    6.005E-01      B2(STR):width of stringer base, b2 (must be > 0, see Help): STR seg=2 , lay
 3   STR   3     0    7.716E-01       H(STR):height of stiffener (type H for sketch), h: STR seg=3 , layer=NA
 4   SKN   1     1    4.614E-02   T(1 )(SKN):thickness for layer index no.(1 ): SKN seg=1 , layer=1
 5   STR   3     1    7.386E-02   T(2 )(STR):thickness for layer index no.(2 ): STR seg=3 , layer=1
 6         0     0    1.177E+01       B(RNG):stiffener spacing, b: RNG seg=NA, layer=NA
 7   RNG   2     0    0.000E+00      B2(RNG):width of ring base, b2 (zero is allowed): RNG seg=2 , layer=NA
 8   RNG   3     0    1.422E+00       H(RNG):height of stiffener (type H for sketch), h: RNG seg=3 , layer=NA
 9   RNG   3     1    6.743E-02   T(3 )(RNG):thickness for layer index no.(3 ): RNG seg=3 , layer=1

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

Table 74 (p.2 of 2)

```
0
  CORRESPONDING VALUE OF THE OBJECTIVE FUNCTION:
 VAR. STR/ SEG. LAYER   CURRENT
 NO.  RNG  NO.   NO.     VALUE           DEFINITION
            0     0   8.462E+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   1.792E+00      B(STR):stiffener spacing, b: STR seg=NA, layer=NA
  2   STR   2     0   5.972E-01     B2(STR):width of stringer base, b2 (must be > 0, see Help): STR seg=2 , lay
  3   STR   3     0   7.712E-01      H(STR):height of stiffener (type H for sketch), h: STR seg=3 , layer=NA
  4   SKN   1     1   4.635E-02   T(1 )(SKN):thickness for layer index no.(1 ): SKN seg=1 , layer=1
  5   STR   3     1   7.238E-02   T(2 )(STR):thickness for layer index no.(2 ): STR seg=3 , layer=1
  6         0     0   1.177E+01      B(RNG):stiffener spacing, b: RNG seg=NA, layer=NA
  7   RNG   2     0   0.000E+00     B2(RNG):width of ring base, b2 (zero is allowed): RNG seg=2 , layer=NA
  8   RNG   3     0   1.464E+00      H(RNG):height of stiffener (type H for sketch), h: RNG seg=3 , layer=NA
  9   RNG   3     1   6.659E-02   T(3 )(RNG):thickness for layer index no.(3 ): RNG seg=3 , layer=1

 **************************************************
 ******************* DESIGN OBJECTIVE ******************
 *************                           ***********
0
  CORRESPONDING VALUE OF THE OBJECTIVE FUNCTION:
 VAR. STR/ SEG. LAYER   CURRENT
 NO.  RNG  NO.   NO.     VALUE           DEFINITION
            0     0   8.448E+01   WEIGHT OF THE ENTIRE PANEL

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

optimum design after 3 executions of PANDAOPT

~~207~~ 217

Table 75 nasaortho2.CPL

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

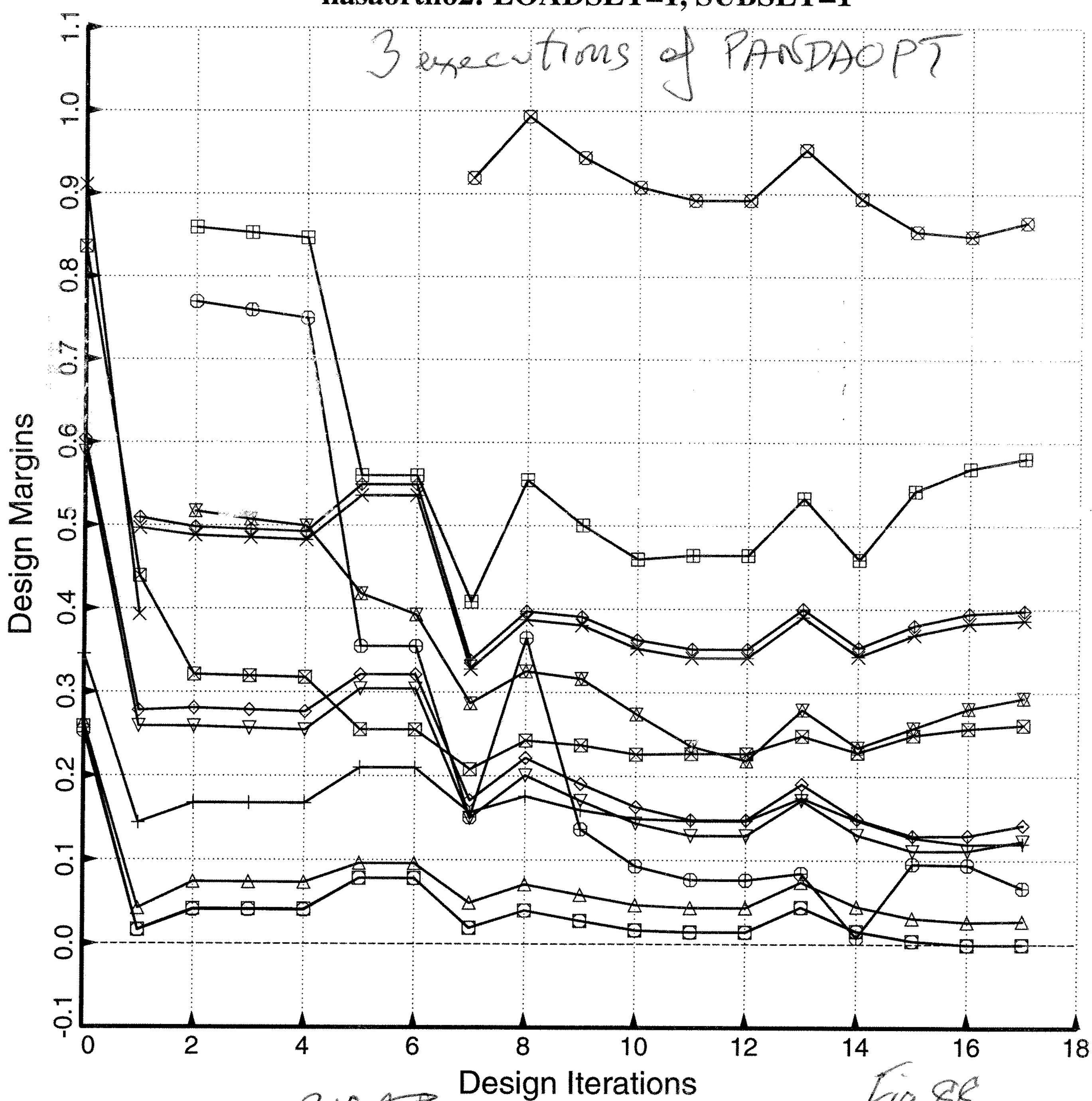
Input for CHOOSEPLOT

Margin #
Load Case 1
Subcase 1

Output from DIPLOT = nasaortho23.ps

□ 1 .1.1 Local buckling: discrete model
○ 2 .1.1 Bending-torsion buckling
△ 3 .1.1 Bending-torsion buckling: Koiter theory.
+ 4 .1.1 m=? lateral-torsional buckling
× 5 .1.1 Inter-ring buckling, discrete model
◇ 6 .1.1 buckling: stringer seg.3 . MIDLENGTH
▽ 7 .1.1 buckling: stringer seg.3 . NO POSTBK
⊠ 8 .1.1 buck(SAND)simp-support general buck; MIDLENGTH
⋇ 9 .1.1 eff.stress:matl=2; MID.
⟠ 10.1.1 eff.stress:matl=2;-MID.
⊕ 11.1.1 Ring sidesway buck., discrete model
⧗ 12.1.1 Lo-n Inter-ring buc.,discrete model
⊞ 13.1.1 eff.stress:matl=3;-MID.
⊠ 14.1.1 buck(SAND)rolling only of stringers; MIDLENGTH

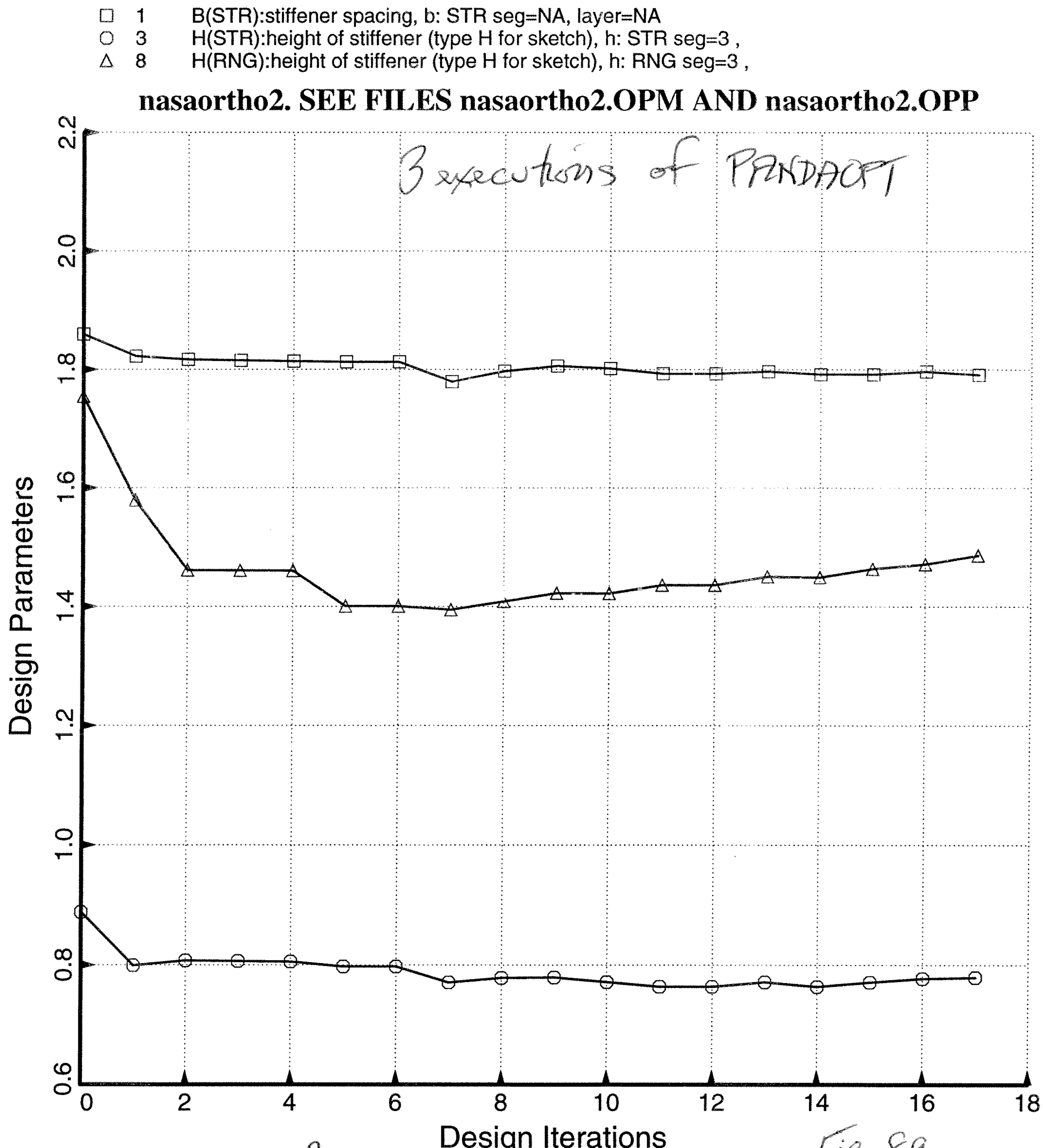
nasaortho2: LOADSET=1, SUBSET=1



219 ~~304~~

Fig. 88

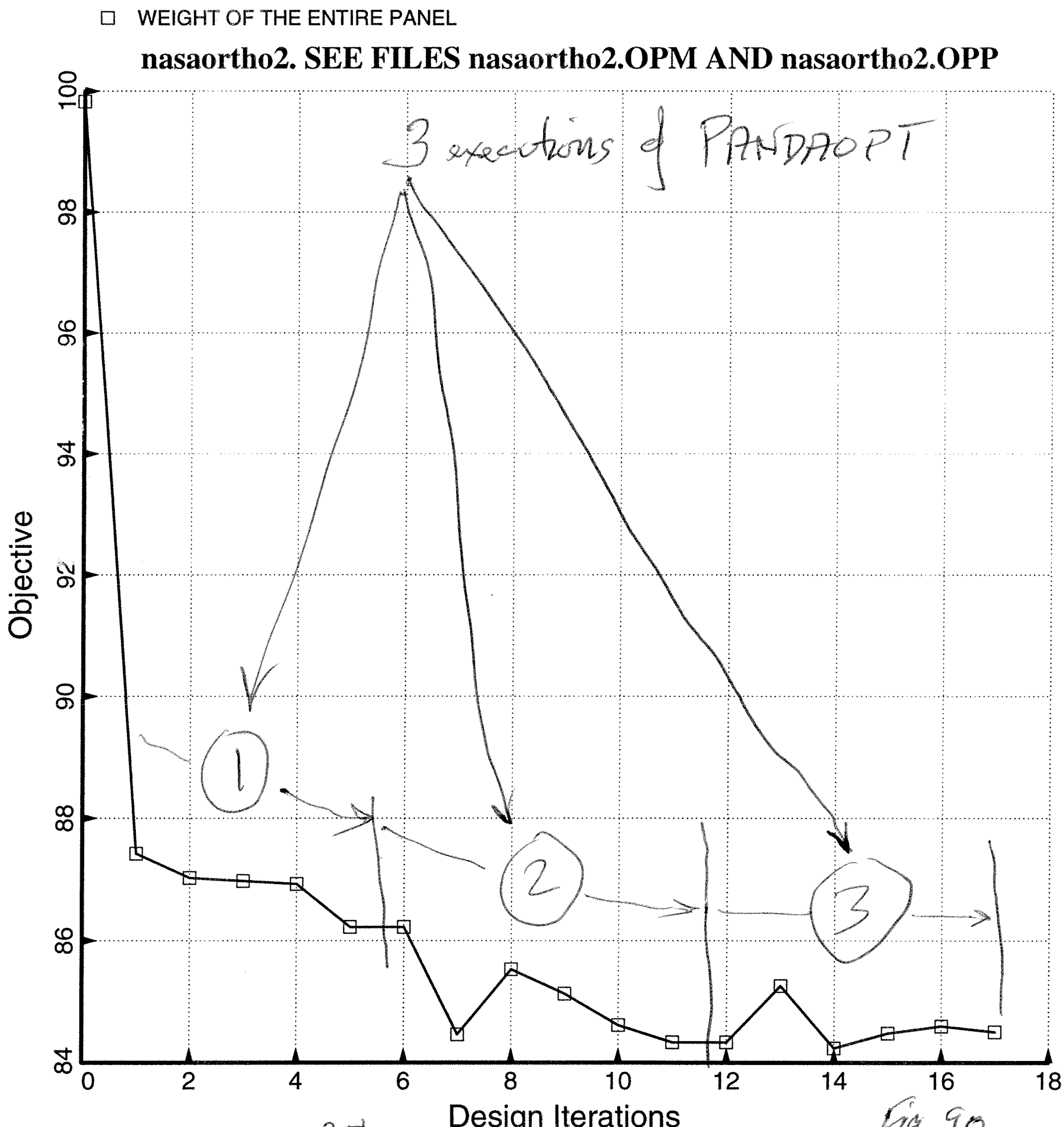
Output from DIPLOT = nasaortho24.ps



~~310~~ 220

Fig. 89

Output from DIPLOT = nasaortho2.5.ps



~~2~~ 221

Fig. 90

Table 76 nasaortho2.CPL

```
n          $ Do you want a tutorial session and tutorial output?
y          $ Any design variables to be plotted v. iterations (Y or N)?
  4        $ Choose a variable to be plotted v. iterations (1,2,3,..)
y          $ Any more design variables to be plotted (Y or N) ?
  5        $ Choose a variable to be plotted v. iterations (1,2,3,..)
y          $ Any more design variables to be plotted (Y or N) ?
  9        $ Choose a variable to be plotted v. iterations (1,2,3,..)
n          $ Any more design variables to be plotted (Y or N) ?
y          $ Any design margins to be plotted (Y or N)?
  2        $ 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,..)
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) ?
  1        $ Give maximum value (positive) to be included in plot frame.
n          $ Do you want a plot of the objective v. iterations (Y/N)?
```

Input for CHOOSEPLOT

get plots for more decision variables & more margins.

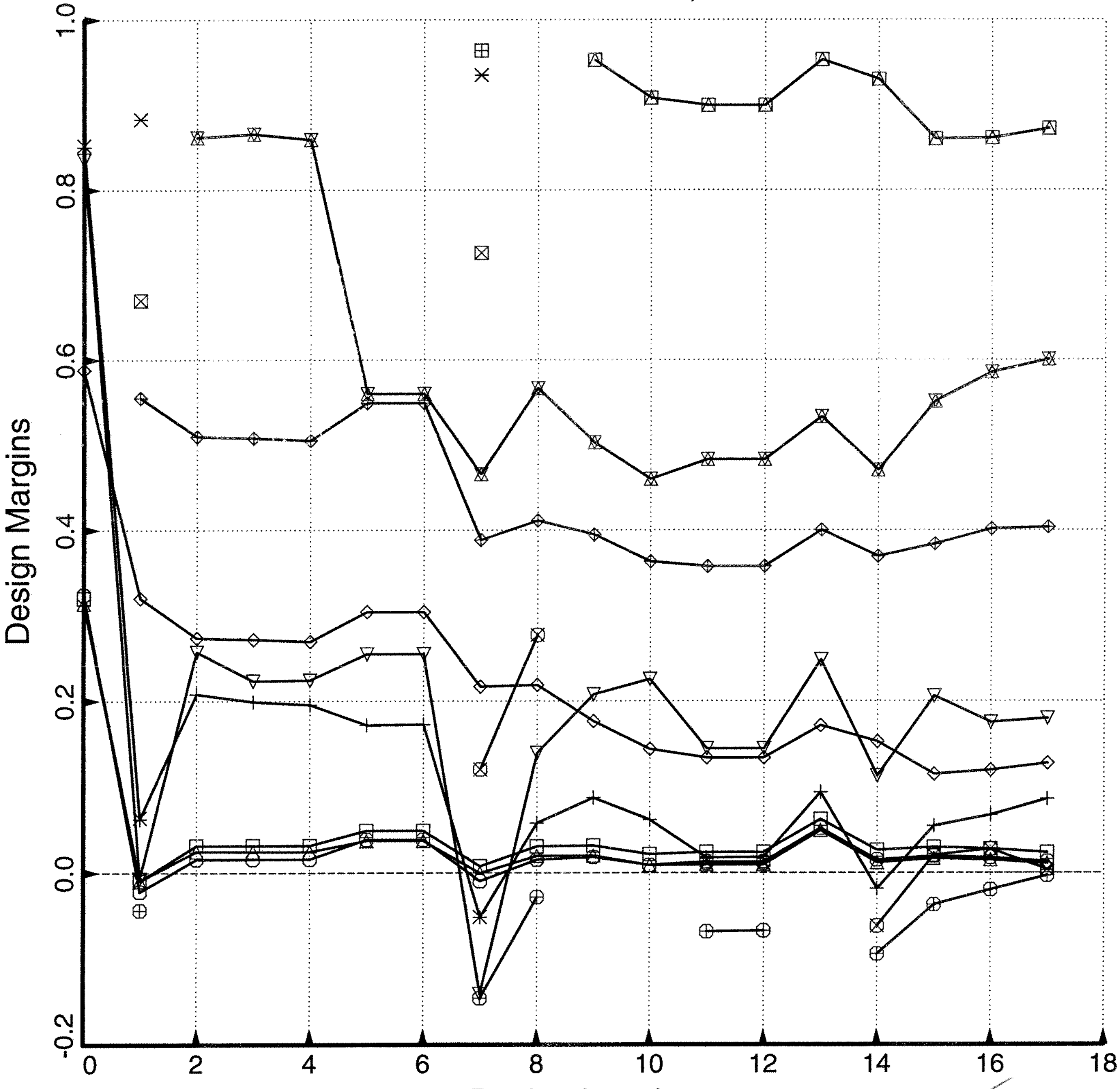
load set
subcase

□ 1 .2.1 Local buckling: discrete model
○ 2 .2.1 Local buckling: Koiter theory.
△ 3 .2.1 m=? lateral-torsional buckling
+ 4 .2.1 Inter-ring buckling, discrete model
× 5 .2.1 Lo-n Inter-ring buc.,discrete model
◇ 6 .2.1 buckling: stringer seg.3 . NO POSTBK
▽ 7 .2.1 buck(SAND)simp-support general buck; MIDLENGTH
⊠ 8 .2.1 eff.stress:matl=1; MID.
⋇ 9 .2.1 eff.stress:matl=2; MID.
⟐ 10.2.1 eff.stress:matl=2;-MID.
⊕ 11.2.1 buck(SAND)rolling with smear string; MIDLENGTH
⧖ 12.2.1 eff.stress:matl=3;-MID.
⊞ 13.2.1 eff.stress:matl=1;-MID.
⊠ 14.2.1 buck(SAND)rolling only of rings; MIDLENGTH
⍂ 15.2.1 buck(SAND)rolling only of stringers; MIDLENGTH

nasaortho2,3.ps

3 executions of PANDA2OPT

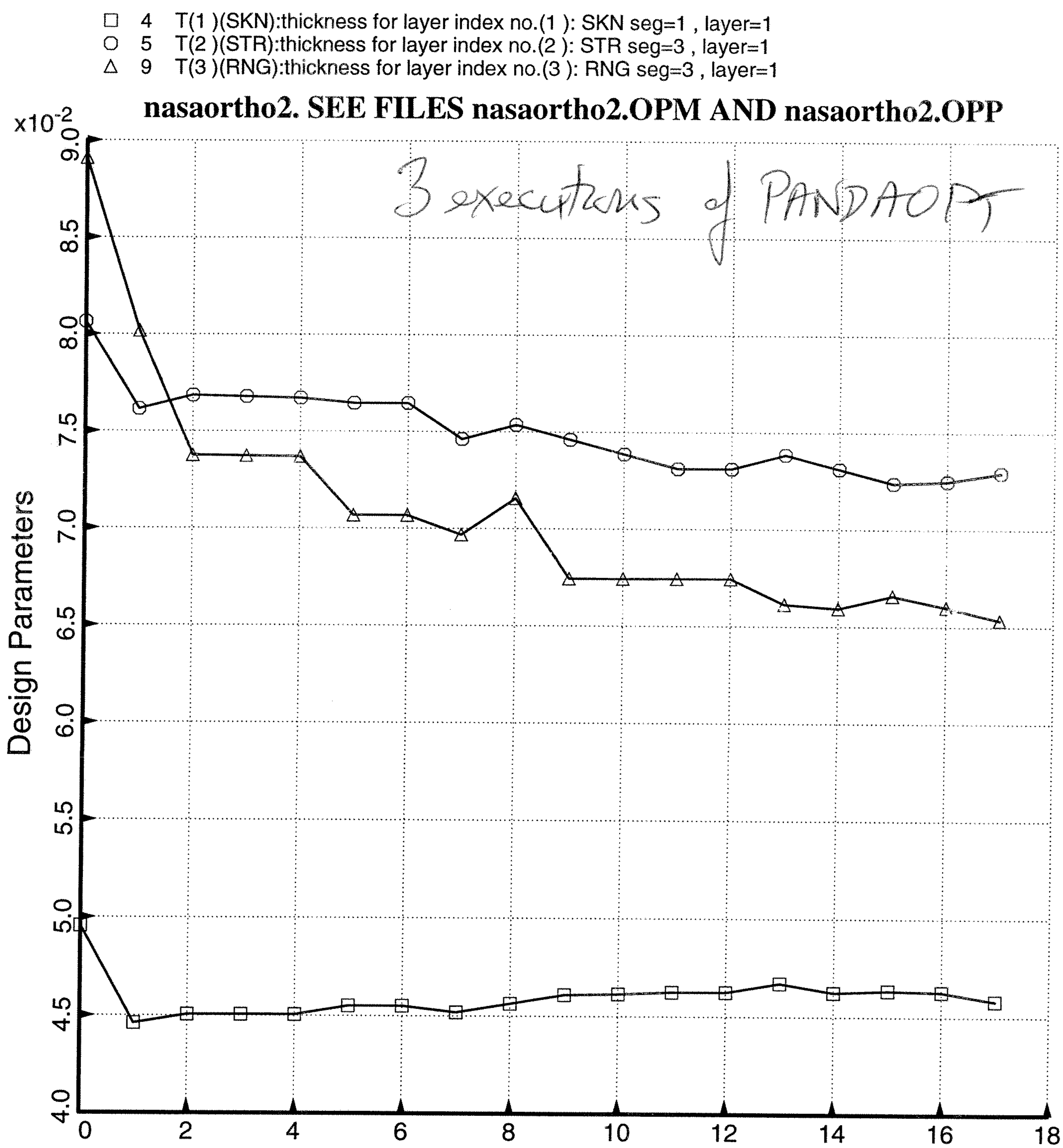
nasaortho2: LOADSET=2, SUBSET=1



~~223~~ 223

Fig. 91

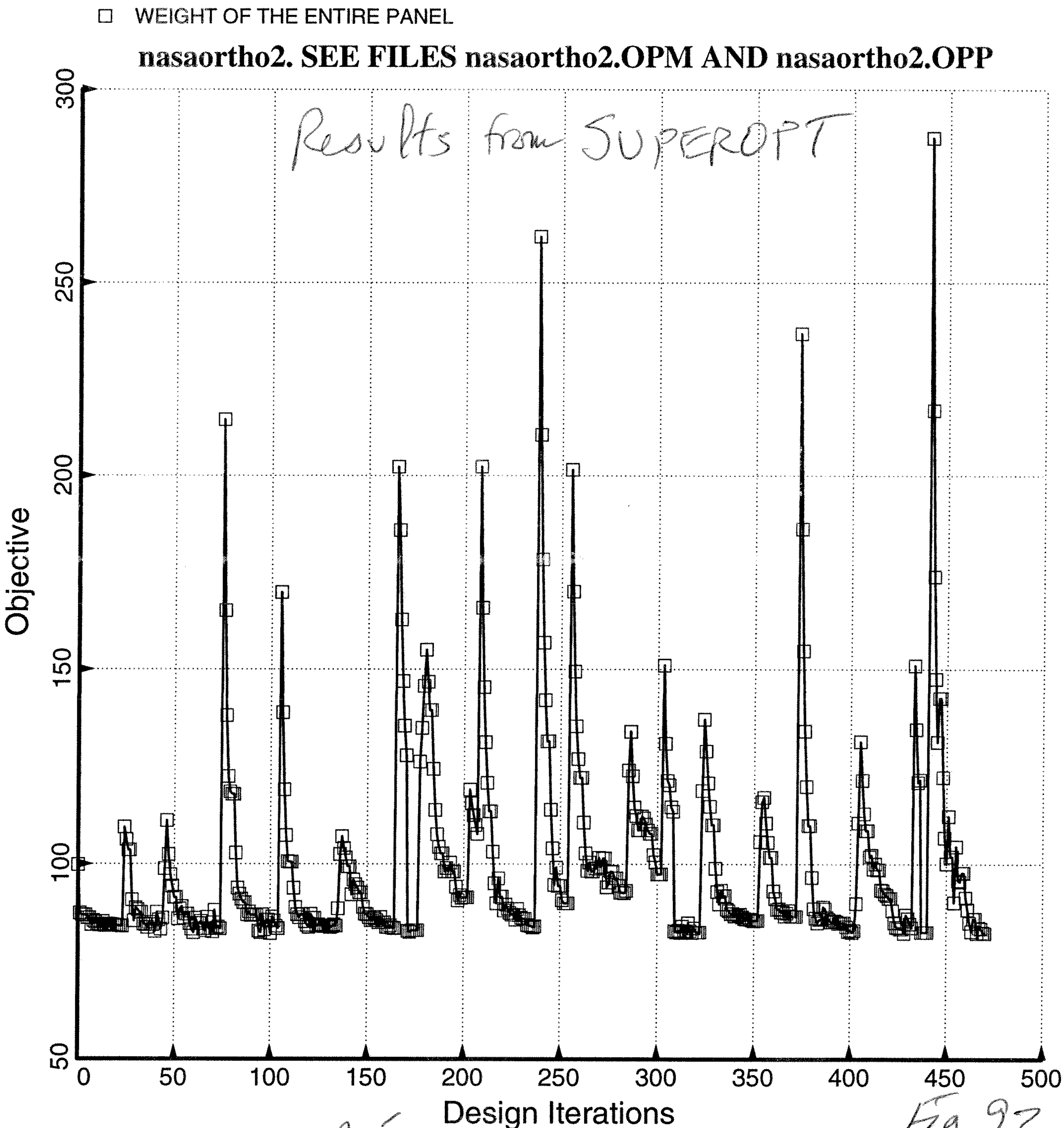
nasaortho2.4.ps



~~311~~ 224

Fig. 92

nasaortho2.5.ps



~~215~~ 225

Fig. 93