Optimum designs from PANDA2 of a uniformly axially compressed cylindrical shell with internal rectangular stringers and rings and with internal substringers and the evaluation of the optimum designs by STAGS and BIGBOSOR4

David Bushnell

25 February, 2009

4 February, 2009

Dear Allen,

I just ran your case. (testcase2, which I call "allen".)

Comments:

1. Indeed there was a bug in PANDA2. I corrected it and accordingly I've entered a new item in .../panda2/doc/panda2.news, as follows:

757. February, 2009
A bug was found in SUBROUTINE BUCPAN of the bucpan1.src library. The bug had to do with the alternative solution corresponding to "altsoln4: buckling of an "intermajorpatch", that is buckling via the alternate (trigonometric expansion) solution for a "patch" between major stringers and major rings. SUBROUTINE BUCPAN was modified as follows:

```
-------------------------------------------------------------------
C  simp-support altsoln4  intermajorpatch
C BEG FEB 2009
            IF (ISTIFX(1).EQ.0.OR.IQUICK.EQ.0)
C END FEB 2009
     1      CALL RECORD(0,24,EALTER(4),SPANDA(4),MPANDA(4),
     1         NPANDA(4),ICONST,CONSTR,WORDB,IFILE,IDESGN,JJJ,1.0,
     1         EIGMAX,IPOINC,INUMTT,FSLOC,ICASE,0,0,VINHOF,
     1         MORCON(ILOADS,ICASE),ENDMID,1,4,1)
-------------------------------------------------------------------
```

The "IF" clause, IF (ISTIFX(1).EQ.0.OR.IQUICK.EQ.0), was added.

2. The run-stream I used and the files of interest are enclosed. I decided to change the case name from "testcase2" to "allen".

3. You ran with IQUICK = 1. When IQUICK = 1 and you have rectangular stiffeners you do not get any alternative buckling solutions, even if you request them.

4. I recommend you use IQUICK = 0. (By the way, if you use IQUICK = 0 the bug described above in 1. is not "active".)

5. Your optimum design has four of your variables at their upper bounds. You should raise the upper bounds of these variables if that is permitted by whatever rules constrain you.

6. Notice that only general buckling constrains the design. This is not a very good optimum, most likely because you enforced upper bounds on H(STR), T(1)(SKN), T(2)(STR), T3(RNG) that should be higher. (H(STR)=height of stringer; T(1)(SKN) = thickness of skin; T(2)(STR) = thickness of stringer; T(3) = thickness of ring).

7. There are several things about the version of the input data that you emailed to me that I advise changing:

*.BEG file:
a. You have such low starting values for H(STR) and H(RNG) and HSUB. This might cause failure to get a "global" optimum design.
b. NB2 should be 1, not zero.
c. For residual stress temperature use 0, not 72 (in PANDA2 TEMPTUR = 0 is the "zero stress temperature", not the ambient temperature).

*.DEC file:
a. You had a "y" for "Any more linked variables" when you meant "n". I'm not sure what this would do. I changed it to "n" before I ran the case.
b. If I understand the inequality constraint properly, you are specifying that the height of the stringer, H(STR), is less than 12 times the thickness of the ring, T(3)(RNG). I don't understand this contraint. Why did you do this?
c. For some reason you linked the height of the ring, H(RNG), to the height of the stringer, H(STR). Why did you do this?

*.OPT file:
a. You set IQUICK = 1 . IQUICK = 0 is much better for this case where you

have stringers. (I ran with IQUICK = 1, however).
b. For the first load set you set factors of safety larger than unity. That might be okay; I don't know in your case. Usually what I do is set the applied load equal to whatever load your panel or shell would have to survive during a demonstration test for a "customer". If the "customer" wants to test the flight article to "ultimate", then you should apply the "ultimate" load and whatever factor of safety is appropriate for that load, probably 1.0.
c. You set FMARG = 0.5. In my opinion the minimum value should be 1.0. I set it to 1.0.
d. You have set the number of design iterations to 25. You should set it to 5 . (I set it to 5).
Because you are the second PANDA2 user at NASA (Prasad was the first that I know of) to set the maximum number of iterations to what in my opinion is much too high a number, I have re-written the "help" paragraph associated with this input datum, as follows (from my version of ...panda/doc/panda2.news):

New item in ...panda2/doc/panda2.news:
756. February, 2009

Too many PANDA2 users have set the number of design iterations to a number that is much too high. The user should use 5, as explained next. Accordingly, the wording of the "introductory" paragraph number 795 in the file, .../panda2/execute/PROMPT.DAT has been changed. This "help" paragraph pertains to the number of design iterations that the user is asked to provide near the end of the MAINSETUP interactive session. As explained in this new paragraph, the user is urged to choose a small number, such as 5 . The new "introductory" paragraph follows:

795.0
Next you will be asked for the number of design iterations. This is the number of iterations corresponding to a single execution of PANDAOPT, not the total number of iterations to be processed for your entire case. It is almost always best to use a small number like 5 iterations. The best optimization strategy is explained in connection with Fig. 83 on p. 582 of the long 1987 PANDA2 paper, "PANDA2 - Program for minimum weight design of stiffened, composite, locally buckled panels. Computers & Structures, Vol. 25, No. 4, pp. 469 - 605, 1987. You should get an optimum design by several executions of PANDAOPT with 5 iterations in each execution. Better yet, use SUPEROPT. With many executions of PANDAOPT and few design iterations with each execution you obtain the most efficient convergence to an optimum design. When you execute SUPEROPT you get more "starting" designs per SUPEROPT run when you use a small number like 5 for the number of iterations, therefore a more complete exploration of design space in the search for the best "global" optimum design. The developer of PANDA2 almost always uses 5 iterations.

I eliminated the bug in PANDA2, then ran the case pretty much according to your input (except for TEMTUR in *.BEG and the "y" that should have been a "n" in *.DEC. The results from this run are listed in Tables 4 - 7 and shown in Fig. 1.

Then I made certain changes according to what I thought would be best for this case and ran again. The results from this second run are listed in Tables 8 - 11 and shown in Fig. 2.

The minimum weight from my second run is dramatically less than that from my first run.

Now I'm running with IQUICK = 0 (the same input as in my second run except that input in *.OPT related to IQUICK). This third run will take lots of computer time, so I'll let it run overnight.

I hope this helps, Allen.

Best regards,

Dave

SUMMARY OF TABLES AND FIGURES ENCLOSED HERE

Tables 1 - 3: the testcase2.BEG .DEC and .OPT files as you emailed them to me, with my comments added.

RUN STREAM: The PANDA2 runs I conducted in this study. (page 7)

Tables 4 - 7 and Fig. 1: results from my first series of PANDA2 runs listed in RUN STREAM (p. 7)

Tables 8 - 11 and Fig. 2: results from my 2nd series of PANDA2 runs where i changed the input as noted because I thought it would be better. (See RUN STREAM p. 7)

Table 1

The input data as you sent it to me

testcom2.BEG

```
n       $ Do you want a tutorial session and tutorial output?
 124    $ Panel length normal to the plane of the screen, L1
622.0353  $ Panel length in the plane of the screen, L2
r       $ Identify type of stiffener along L1 (N,T,J,Z,R,A,C,G)
  8     $ stiffener spacing, b
0.6670000  $ width of stringer base, b2 (must be > 0, see Help)
0.6500000  $ height of stiffener (type H for sketch), h
n       $ Are the stringers cocured with the skin?
10000   $ 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?
0.6500000E-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)
y       $ Any more layers or groups of layers in Segment no.( 1)
n       $ Is the next group of layers to be a "default group"?
y       $ Does one of the additional layers consist of sub-stiffeners?
n       $ Does this sub-stiffener "layer" form an isogrid?
 0      $ Index, NSURF = 0 or 1, for substiffener "layer"( 1)
 0      $ Index, NB2 = 0 or 1, for substiffener "layer"( 1)
0.5000000E-01 $ Thickness, TSUB, of substiffener set( 1)
0.4000000  $ Height, HSUB, of substiffener set( 1)
 0      $ Angle, THSUB (degrees), of substiffener set( 1)
 2      $ Spacing, BSUB, of substiffener set( 1)
 1      $ Material type, MATSUB, for substiffener set( 1)
n       $ Are there any more substiffener sets in substiffener "layer"
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.( )
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.( )
y       $ Is this a new layer type?
0.6500000  $ thickness for layer index no.( 2)
 0      $ winding angle (deg.) for layer index no.( 2)
 1      $ material index (1,2,...) for layer index no.( 2)
n       $ Any more layers or groups of layers in Segment no.( 2)
 1      $ choose external (0) or internal (1) stringers
r       $ Identify type of stiffener along L2 (N, T, J, Z, R, A)
```

starting value too low

use 1

low starting values?

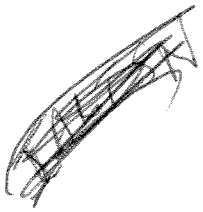

Table B.1 (cont'd) tastene2.BEG, continued

```
       8     $ stiffener spacing, b
       0     $ width of ring base, b2 (zero is allowed)
0.6500000    $ 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?
0.6500000    $ thickness for layer index no.( 3)
       0     $ winding angle (deg.) for layer index no.( 3)
       1     $ 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.)?
     198     $ 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)?
0.1120000E+08 $ Young's modulus,          E( 1)
0.3000000    $ Poisson's ratio,           NU( 1)
 4307692     $ transverse shear modulus,  G13( 1)
       0     $ Thermal expansion coeff.,  ALPHA( 1)
      72     $ 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 ?
   66000     $ Maximum allowable effective stress in material type( 1)
       n     $ Do you want to take advantage of "bending overshoot"?
0.9800000E-01 $ weight density (greater than 0!) of material type( 1)
       n     $ Is lamina cracking permitted along fibers (type H(elp))?
       0     $ Prebuckling: choose 0=bending included; 2=use membrane theory
       0     $ Buckling: choose 0=simple support or 1=clamping
```

starting value too low

use 0

Table2 testcase2.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,...)
0.6500000E-01 $ Lower bound of variable no.( 4)
0.4000000     $ Upper bound of variable no.( 4)
y       $ Any more decision variables (Y or N) ?
1       $ Choose a decision variable (1,2,3,...)
2       $ Lower bound of variable no.( 1)
16      $ Upper bound of variable no.( 1)
y       $ Any more decision variables (Y or N) ?
9       $ Choose a decision variable (1,2,3,...)
2       $ Lower bound of variable no.( 9)
50      $ Upper bound of variable no.( 9)
y       $ Any more decision variables (Y or N) ?
8       $ Choose a decision variable (1,2,3,...)
0.6500000E-01 $ Lower bound of variable no.( 8)
1       $ Upper bound of variable no.( 8)
y       $ Any more decision variables (Y or N) ?
12      $ Choose a decision variable (1,2,3,...)
0.6500000E-01 $ Lower bound of variable no.(12)
1       $ Upper bound of variable no.(12)
y       $ Any more decision variables (Y or N) ?
3       $ Choose a decision variable (1,2,3,...)
0.6500000E-01 $ Lower bound of variable no.( 3)
1.850000      $ Upper bound of variable no.( 3)
y       $ Any more decision variables (Y or N) ?
6       $ Choose a decision variable (1,2,3,...)
0       $ Lower bound of variable no.( 6)
10.5    $ Upper bound of variable no.( 6)
y       $ Any more decision variables (Y or N) ?
7       $ Choose a decision variable (1,2,3,...)
0       $ Lower bound of variable no.( 7)
8       $ Upper bound of variable no.( 7)
y       $ Any more decision variables (Y or N) ?
5       $ Choose a decision variable (1,2,3,...)
0       $ Lower bound of variable no.( 5)
5.000000      $ Upper bound of variable no.( 5)
n       $ Any more decision variables (Y or N) ?
y       $ Any linked variables (Y or N) ?
2       $ Choose a linked variable (1,2,3,...)
1       $ To which variable is this variable linked?
0.3330000     $ 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)?
y       $ Any more linked variables (Y or N) ?
11      $ Choose a linked variable (1,2,3,...)
```

Table 2 (continued)

```
     3     $ To which variable is this variable linked?
 1.000000  $ 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)?
     y     $ Any more linked variables (Y or N) ?
     y     $ Any inequality relations among variables? (type H)
     y     $ Want to see an example of how to calculate C0, C1, D1...?
     1     $ Identify the type of inequality expression (1 or 2)
 1.000000  $ Give a value to the constant, C0
     n     $ Are there any cross product terms in the inequality expression?
     3     $ Choose a variable from the list above (1, 2, 3,...)
    -1     $ Choose a value for the coefficient, C1
     1     $ Choose a value for the power, D1
     y     $ Any more terms in the expression: C0 +C1*v1**D1 +C2*v2**D2 +...
    12     $ Choose a variable from the list above (1, 2, 3,...)
    12     $ Choose a value for the coefficient, Cn
     1     $ Choose a value for the power, Dn
     n     $ Any more terms in the expression: C0 +C1*v1**D1 +C2*v2**D2 +...
     n     $ Are there any more inequality expressions?
     y     $ Any escape variables (Y or N) ?
     y     $ Want to have escape variables chosen by default?
```

should be n ?

) why do you want H(RNG)=H(STR)

according to this constraint:

$H(STR) \quad T(3)(RNG)$

$1 < 1 - V(3) + 12\,V(12)$

or

$H(STR) < 12\,T(3)(RNG)$

This does not make sense to me!

if

testcon2.OPT Table 3

```
n       $ Do you want a tutorial session and tutorial output?
-8025     $ 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?
  1     $ IQUICK = quick analysis indicator (0 or 1)
2.153846    $ Factor of safety for general instability, FSGEN( 1)
1.555556    $ Factor of safety for panel (between rings) instability, FSPAN( 1)
1.555556    $ Minimum load factor for local buckling (Type H for HELP), FSLOC( 1)
1.555556    $ Minimum load factor for stiffener buckling (Type H), FSBSTR( 1)
  1     $ 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     $ Resultant (e.g. lb/in) normal to the plane of screen, Nx0( 1)
  0     $ Resultant (e.g. lb/in) in the plane of the screen,   Ny0( 1)
  1     $ Axial load applied along the (0=neutral plane), (1=panel skin)
  0     $ Uniform applied pressure [positive upward. See H(elp)], p( 1)
  0     $ Out-of-roundness, Wimpg1=(Max.diameter-Min.diam)/4, Wimpg1( 1)
  0     $ Initial buckling modal general imperfection amplitude, Wimpg2( 1)
  0     $ 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)
  0     $ 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 ?
-8025     $ Resultant (e.g. lb/in) normal to the plane of screen, Nx( 2)
  0     $ Resultant (e.g. lb/in) in the plane of the screen,   Ny( 2)
  0     $ In-plane shear in load set A,              Nxy( 2)
n       $ Does the axial load vary in the L2 direction?
  0     $ Applied axial moment resultant (e.g. in-lb/in), Mx( 2)
  0     $ Applied hoop moment resultant (e.g. in-lb/in), My( 2)
y       $ Want to include effect of transverse shear deformation?
  1     $ IQUICK = quick analysis indicator (0 or 1)
  1     $ Factor of safety for general instability, FSGEN( 2)
  1     $ Factor of safety for panel (between rings) instability, FSPAN( 2)
  1     $ Minimum load factor for local buckling (Type H for HELP), FSLOC( 2)
  1     $ Minimum load factor for stiffener buckling (Type H), FSBSTR( 2)
1.265753    $ Factor of safety for stress, FSSTR( 2)
y       $ Do you want "flat skin" discretized module for local buckling?
n       $ Do you want wide-column buckling to constrain the design?
  0     $ Resultant (e.g. lb/in) normal to the plane of screen, Nx0( 2)
```

Table 3 (continued)

```
11266.20     $ Resultant (e.g. lb/in) in the plane of the screen.  Ny0( 2)
    1        $ Axial load applied along the (0=neutral plane, 1=panel skin)
-56.90000    $ Uniform applied pressure [positive upward. See H(elp)], p( 2)
    n        $ Is the pressure part of Load Set A?
    n        $ Is the pressure hydrostatic (Type H for "HELP")?
    0        $ Choose in-plane immovable (IFREE=0) or movable (IFREE=1) b.c.( 2)
    y        $ Are you feeling well today (type H)?
    n        $ Is there a maximum allowable deflection due to pressure?
    0        $ Out-of-roundness, Wimpg1=(Max.diameter-Min.diam)/4, Wimpg1( 2)
    0        $ Initial buckling modal general imperfection amplitude, Wimpg2( 2)
    0        $ Initial buckling modal inter-ring imperfection amplitude,Wpan( 2)
0.1000000E-06 $ Initial local imperfection amplitude (must be positive), Wloc( 2)
    n        $ Do you want PANDA2 to change imperfection amplitudes (see H(elp))?( 2)
    y        $ Do you want PANDA2 to find the general imperfection shape?( 2)
    0        $ Maximum allowable average axial strain (type H for HELP)( 2)
    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)
    0        $ Index for type of shell theory (0 or 1 or 2), ISAND
    n        $ Does the postbuckling axial wavelength of local buckles change?
    n        $ 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)
    n        $ Do you want to prevent secondary buckling (mode jumping)?
    y        $ Do you want to use the "alternative" buckling solution?
1.000000     $ Factor of safety for "alternative" model of general buckling
   25        $ How many design iterations permitted in this run (5 to 25)?
    1        $ 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)
0.5000000    $ FMARG (Skip load case with min. margin greater than FMARG)
```

ok

use 5

use 1.0

RUN STREAM USED TO OBTAIN MY RESULTS

```
panda2log
begin           Table 4
setup
decide          Table 5
mainsetup       Table 6
superopt
(inspect the allen.OPP file)
chooseplot
diplot
(inspect the allen.5.ps file)   Fig. 1
(edit allen.OPT to get fixed design: ITYPE = 2)
mainsetup
pandaopt
(inspect the allen.OPM file.)   Table 7

(Next, change the *.BEG and *.DEC files
 as appropriate and optimize again:
 1, In *.BEG use higher starting values
    for H(STR), H(RNG), TSUB and HSUB (substringer)
 2. In *.BEG change NB2 from 0 to 1
 3. In *.DEC put higher upper bounds on
    H(STR), T(1)(SKN), T(2)(STR), t(3)(RNG)
 4. In *.DEC add H(RNG) as a decision variable
 5. In *.DEC eliminate the peculiar inequality
    constraint.
 6. In *.DEC eliminate the 2nd linking
    expression (where H(RNG) = H(STR)).

begin           Table 8
setup
decide          Table 9
mainsetup       Table 10
superopt
(inspect the allen.OPP file)
chooseplot
diplot
(inspect the allen.5.ps file)   Fig. 2
(edit allen.OPT to get fixed design: ITYPE = 2)
mainsetup
pandaopt
(inspect the allen.OPM file.)   Table 11
```

Table 4 allen.BEG

```
n              $ Do you want a tutorial session and tutorial output?
 124           $ Panel length normal to the plane of the screen, L1
622.0353       $ Panel length in the plane of the screen, L2
r              $ Identify type of stiffener along L1 (N,T,J,Z,R,A,C,G)
8              $ stiffener spacing, b
0.6670000      $ width of stringer base, b2 (must be > 0, see Help)
0.6500000      $ height of stiffener (type H for sketch), h
n              $ Are the stringers cocured with the skin?
10000          $ 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?
0.6500000E-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)
y              $ Any more layers or groups of layers in Segment no.( 1)
n              $ Is the next group of layers to be a "default group"?
y              $ Does one of the additional layers consist of sub-stiffeners?
n              $ Does this sub-stiffener "layer" form an isogrid?
0              $ Index, NSURF = 0 or 1, for substiffener "layer"( 1)
0              $ Index, NB2 = 0 or 1, for substiffener "layer"( 1)
0.5000000E-01  $ Thickness, TSUB, of substiffener set( 1)
0.4000000      $ Height, HSUB, of substiffener set( 1)
0              $ Angle, THSUB (degrees), of substiffener set( 1)
2              $ Spacing, BSUB, of substiffener set( 1)
1              $ Material type, MATSUB,  for substiffener set( 1)
n              $ Are there any more substiffener sets in substiffener "layer"
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?
0.6500000      $ thickness for layer index no.( 2)
0              $ winding angle (deg.) for layer index no.( 2)
1              $ 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)
8              $ stiffener spacing, b
0              $ width of ring base, b2 (zero is allowed)
0.6500000      $ 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?
0.6500000      $ thickness for layer index no.( 3)
0              $ winding angle (deg.) for layer index no.( 3)
1              $ 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.)?
 198           $ 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)?
0.1120000E+08  $ Young's modulus,                  E( 1)
0.3000000      $ Poisson's ratio,                 NU( 1)
4307692.       $ 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 ?
66000.00       $ Maximum allowable effective stress in material type( 1)
n              $ Do you want to take advantage of "bending overshoot"?
0.9800000E-01  $ weight density (greater than 0!) of material type( 1)
n              $ Is lamina cracking permitted along fibers (type H(elp))?
0              $ Prebuckling: choose 0=bending included; 2=use membrane theory
0              $ Buckling: choose 0=simple support or 1=clamping
```

should have changed this to 1

Tables allen.VEC

```
     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,...)
 0.6500000E-01  $ Lower bound of variable no.( 4)
 0.4000000      $ Upper bound of variable no.( 4)
     y          $ Any more decision variables (Y or N) ?
        1       $ Choose a decision variable (1,2,3,...)
        2       $ Lower bound of variable no.( 1)
       16       $ Upper bound of variable no.( 1)
     y          $ Any more decision variables (Y or N) ?
        9       $ Choose a decision variable (1,2,3,...)
        2       $ Lower bound of variable no.( 9)
       50       $ Upper bound of variable no.( 9)
     y          $ Any more decision variables (Y or N) ?
        8       $ Choose a decision variable (1,2,3,...)
 0.6500000E-01  $ Lower bound of variable no.( 8)
        1       $ Upper bound of variable no.( 8)
     y          $ Any more decision variables (Y or N) ?
       12       $ Choose a decision variable (1,2,3,...)
 0.6500000E-01  $ Lower bound of variable no.(12)
        1       $ Upper bound of variable no.(12)
     y          $ Any more decision variables (Y or N) ?
        3       $ Choose a decision variable (1,2,3,...)
 0.6500000E-01  $ Lower bound of variable no.( 3)
  1.850000      $ Upper bound of variable no.( 3)
     y          $ Any more decision variables (Y or N) ?
        6       $ Choose a decision variable (1,2,3,...)
        0       $ Lower bound of variable no.( 6)
  10.50000      $ Upper bound of variable no.( 6)
     y          $ Any more decision variables (Y or N) ?
        7       $ Choose a decision variable (1,2,3,...)
        0       $ Lower bound of variable no.( 7)
        8       $ Upper bound of variable no.( 7)
     y          $ Any more decision variables (Y or N) ?
        5       $ Choose a decision variable (1,2,3,...)
        0       $ Lower bound of variable no.( 5)
        5       $ Upper bound of variable no.( 5)
     n          $ Any more decision variables (Y or N) ?
     y          $ Any linked variables (Y or N) ?
        2       $ Choose a linked variable (1,2,3,...)
        1       $ To which variable is this variable linked?
 0.3330000      $ 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)?
     y          $ Any more linked variables (Y or N) ?
       11       $ Choose a linked variable (1,2,3,...)
        3       $ To which variable is this variable linked?
        1       $ 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) ?
     y          $ Any inequality relations among variables? (type H)
     y          $ Want to see an example of how to calculate C0, C1, D1,..?
        1       $ Identify the type of inequality expression (1 or 2)
        1       $ Give a value to the constant, C0
     n          $ Are there any cross product terms in the inequality expression?
        3       $ Choose a variable from the list above (1, 2, 3,...)
       -1       $ Choose a value for the coefficient, C1
        1       $ Choose a value for the power, D1
     y          $ Any more terms in the expression: C0 +C1*v1**D1 +C2*v2**D2 +...
       12       $ Choose a variable from the list above (1, 2, 3,...)
       12       $ Choose a value for the coefficient, Cn
        1       $ Choose a value for the power, Dn
     n          $ Any more terms in the expression: C0 +C1*v1**D1 +C2*v2**D2 +...
     n          $ Are there any more inequality expressions?
     y          $ Any escape variables (Y or N) ?
     y          $ Want to have escape variables chosen by default?
```

I kept this for now, but eliminated it later.

Table 6 allen.OPT

```
     n          $ Do you want a tutorial session and tutorial output?
    -8025       $ 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?
        1       $ IQUICK = quick analysis indicator (0 or 1)
 2.153846       $ Factor of safety for general instability, FSGEN( 1)
 1.555556       $ Factor of safety for panel (between rings) instability, FSPAN( 1)
 1.555556       $ Minimum load factor for local buckling (Type H for HELP), FSLOC( 1)
 1.555556       $ Minimum load factor for stiffener buckling (Type H), FSBSTR( 1)
        1       $ 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       $ Resultant (e.g. lb/in) normal to the plane of screen, Nx0( 1)
        0       $ Resultant (e.g. lb/in) in the plane of the screen,    Ny0( 1)
        1       $ Axial load applied along the (0=neutral plane), (1=panel skin)
        0       $ Uniform applied pressure [positive upward. See H(elp)], p( 1)
        0       $ Out-of-roundness, Wimpg1=(Max.diameter-Min.diam)/4, Wimpg1( 1)
        0       $ Initial buckling modal general imperfection amplitude, Wimpg2( 1)
        0       $ Initial buckling modal inter-ring imperfection amplitude,Wpan( 1)
        0       $ 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)
        0       $ 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 ?
    -8025       $ Resultant (e.g. lb/in) normal to the plane of screen, Nx( 2)
        0       $ Resultant (e.g. lb/in) in the plane of the screen,    Ny( 2)
        0       $ In-plane shear in load set A,                  Nxy( 2)
     n          $ Does the axial load vary in the L2 direction?
        0       $ Applied axial moment resultant (e.g. in-lb/in), Mx( 2)
        0       $ Applied hoop moment resultant (e.g. in-lb/in), My( 2)
     y          $ Want to include effect of transverse shear deformation?
        1       $ IQUICK = quick analysis indicator (0 or 1)
        1       $ Factor of safety for general instability, FSGEN( 2)
        1       $ Factor of safety for panel (between rings) instability, FSPAN( 2)
        1       $ Minimum load factor for local buckling (Type H for HELP), FSLOC( 2)
        1       $ Minimum load factor for stiffener buckling (Type H), FSBSTR( 2)
 1.265753       $ Factor of safety for stress, FSSTR( 2)
     y          $ Do you want "flat skin" discretized module for local buckling?
     n          $ Do you want wide-column buckling to constrain the design?
        0       $ Resultant (e.g. lb/in) normal to the plane of screen, Nx0( 2)
 11266.20       $ Resultant (e.g. lb/in) in the plane of the screen,    Ny0( 2)
        1       $ Axial load applied along the (0=neutral plane), (1=panel skin)
-56.90000       $ Uniform applied pressure [positive upward. See H(elp)], p( 2)
     n          $ Is the pressure part of Load Set A?
     n          $ Is the pressure hydrostatic (Type H for "HELP")?
        0       $ Choose in-plane immovable (IFREE=0) or movable (IFREE=1) b.c.( 2)
     y          $ Are you feeling well today (type H)?
     n          $ Is there a maximum allowable deflection due to pressure?
        0       $ Out-of-roundness, Wimpg1=(Max.diameter-Min.diam)/4, Wimpg1( 2)
        0       $ Initial buckling modal general imperfection amplitude, Wimpg2( 2)
        0       $ Initial buckling modal inter-ring imperfection amplitude,Wpan( 2)
        0       $ Initial local imperfection amplitude (must be positive), Wloc( 2)
     n          $ Do you want PANDA2 to change imperfection amplitudes (see H(elp))?( 2)
     y          $ Do you want PANDA2 to find the general imperfection shape?( 2)
        0       $ Maximum allowable average axial strain (type H for HELP)( 2)
     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)
        0       $ Index for type of shell theory (0 or 1 or 2), ISAND
     n          $ Does the postbuckling axial wavelength of local buckles change?
     n          $ 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)
     Y          $ Do you want to prevent secondary buckling (mode jumping)?
```

. Table 6 (cont'd) allen.OPT (concluded)

```
     Y          $ Do you want to use the "alternative" buckling solution?
   1.0
       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)
```

allen.5.ps

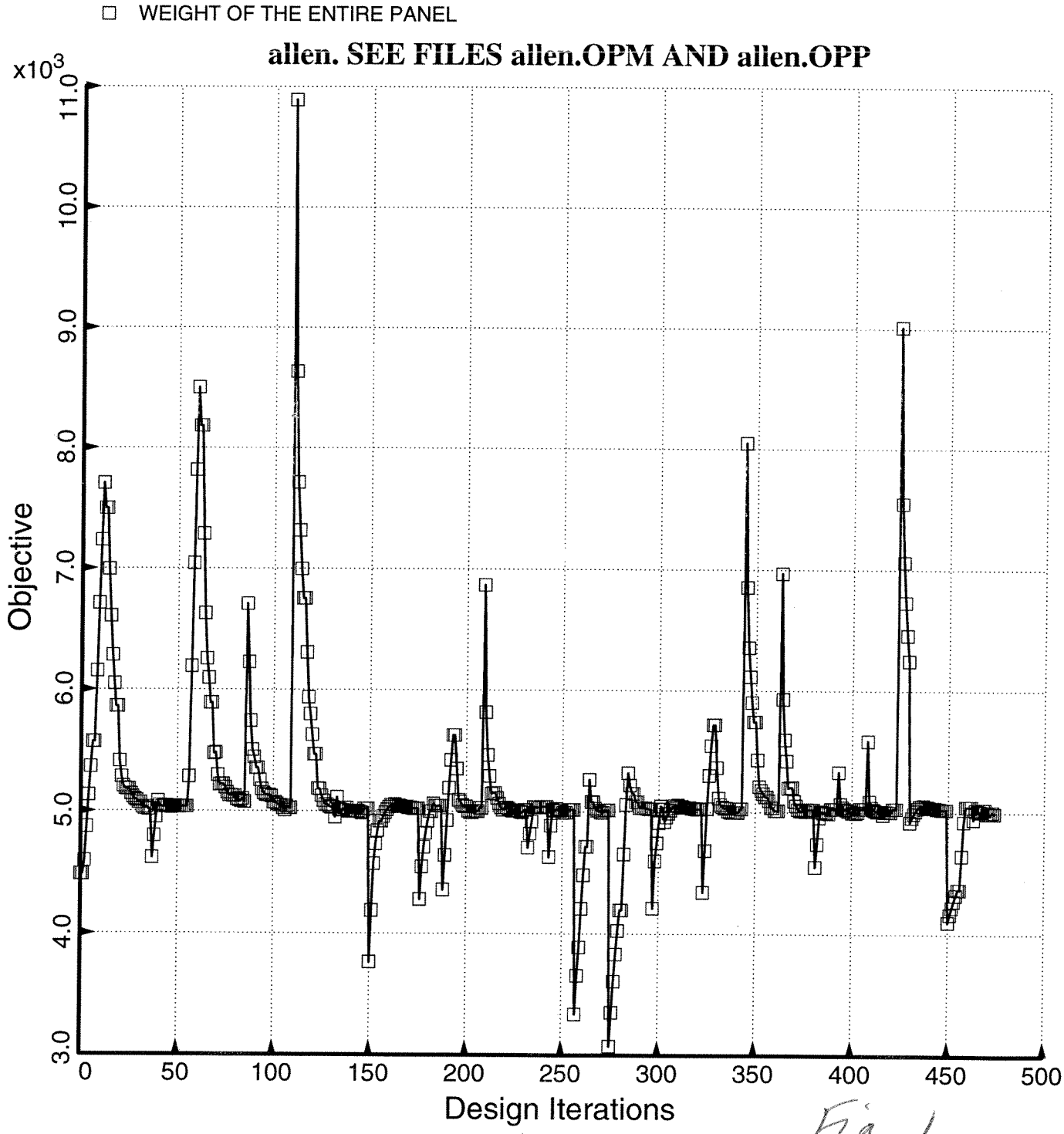

Fig. 1

Table 7 (3 pages)

allen.OPM (abridged) after one SUPEROPT execution (IQUICK=1)

```
*************** LOAD CASE NO. 1  ****************
***NOTE: Rectangular stringers and IQUICK( 1)=1
Therefore, there will be no alternate buckling solns
for this load case.

ANALYSIS: ITYPE=2;  IQUICK=1;  LOAD SET 1;  SUBCASE 1:
LOADING: Nx, Ny, Nxy, Mx, My =  -8.02E+03 -8.02E-03  4.01E+01  0.00E+00  0.00E+00
         Nxo, Nyo, pressure  =   0.00E+00  0.00E+00  4.05E-05

MARGINS FOR CURRENT DESIGN: LOAD CASE NO. 1, SUBCASE NO. 1
MAR. MARGIN
NO.  VALUE                DEFINITION
 1  1.89E+00 Inter-ring bucklng, discrete model, n=15  circ.halfwaves;FS=1.5556
 2  3.69E+00 matl=1 ; substiffener effective stressSTRCON MID.;FS=1.
 3  3.61E+00 eff.stress:matl=1,STR,Iseg=3,at:TIP,layer=1,z=0.;-MID.;FS=1.
 4  4.32E+01 buckling margin stringer Iseg.3 . Local halfwaves=2  .MID.;FS=1.555
 5  1.08E+00 buck.(DONL);simp-support smearsubstf; M=2;N=1;slope=0.;FS=1.5556
 6  5.11E+00 buck.(DONL);simp-support smear rings; M=23;N=1;slope=0.;FS=1.5556
 7 -4.05E-02 buck.(DONL);simp-support general buck;M=2;N=11;slope=0.;FS=2.1538
 8  3.52E+00 buck.(DONL);rolling with smearsubstf; M=2;N=1;slope=0.;FS=1.5556
 9  6.52E+00 buck.(DONL);rolling with smear rings; M=22;N=1;slope=0.;FS=1.5556
10  9.36E+01 buck.(DONL);rolling only of stringers;M=40;N=0;slope=0.;FS=1.4
11  8.01E+00 buck.(DONL);rolling with skin buckl.; M=4;N=1;slope=0.;FS=1.5556
12  1.53E+02 buckling:simp-support of substring.M=4;FS=1.
13  7.97E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
14  5.49E+00 1.-V(3)^1+12.V(12)^1-1
15  1.08E+00 buck.(SAND);simp-support smearsubstf; M=2;N=1;slope=0.;FS=1.5556
16  5.11E+00 buck.(SAND);simp-support smear rings; M=23;N=1;slope=0.;FS=1.5556
17 -4.72E-02 buck.(SAND);simp-support general buck;M=2;N=11;slope=0.;FS=2.1538
18  3.52E+00 buck.(SAND);rolling with smearsubstf; M=2;N=1;slope=0.;FS=1.5556
19  6.52E+00 buck.(SAND);rolling with smear rings; M=22;N=1;slope=0.;FS=1.5556
20  8.01E+00 buck.(SAND);rolling with skin buckl.; M=4;N=1;slope=0.;FS=1.5556


****************************************
ITERATION NO., LOAD SET NO., SUBCASE NO. =   0   1   2     AT RINGS
****************************************

ANALYSIS: ITYPE=2;  IQUICK=1;  LOAD SET 1;  SUBCASE 2:
LOADING: Nx, Ny, Nxy, Mx, My =  -8.02E+03 -8.02E-03  4.01E+01  0.00E+00  0.00E+00
         Nxo, Nyo, pressure  =   0.00E+00  0.00E+00  4.05E-05

MARGINS FOR CURRENT DESIGN: LOAD CASE NO. 1, SUBCASE NO. 2
MAR. MARGIN
NO.  VALUE                DEFINITION
 1  1.89E+00 Inter-ring bucklng, discrete model, n=15  circ.halfwaves;FS=1.5556
 2  3.71E+00 matl=1 ; substiffener effective stressSTRCON RNGS;FS=1.
 3  3.71E+00 eff.stress:matl=1,STR,Iseg=3,at:ROOT,layer=1,z=0.;-RNGS;FS=1.
 4  4.52E+01 buckling margin stringer Iseg.3 . Local halfwaves=2  .RNGS;FS=1.555
 5  1.07E+00 buck.(DONL);simp-support smearsubstf; M=2;N=1;slope=0.;FS=1.5556
 6  5.09E+00 buck.(DONL);simp-support smear rings; M=23;N=1;slope=0.;FS=1.5556
 7  3.51E+00 buck.(DONL);rolling with smearsubstf; M=2;N=1;slope=0.;FS=1.5556
 8  6.50E+00 buck.(DONL);rolling with smear rings; M=22;N=1;slope=0.;FS=1.5556
 9  9.70E+01 buck.(DONL);rolling only of stringers;M=40;N=0;slope=0.;FS=1.4
10  7.97E+00 buck.(DONL);rolling with skin buckl.; M=4;N=1;slope=0.;FS=1.5556
11  1.54E+02 buckling:simp-support of substring.M=4;FS=1.
12  7.95E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
13  1.07E+00 buck.(SAND);simp-support smearsubstf; M=2;N=1;slope=0.;FS=1.5556
14  5.09E+00 buck.(SAND);simp-support smear rings; M=23;N=1;slope=0.;FS=1.5556
15  3.51E+00 buck.(SAND);rolling with smearsubstf; M=2;N=1;slope=0.;FS=1.5556
16  6.50E+00 buck.(SAND);rolling with smear rings; M=22;N=1;slope=0.;FS=1.5556
17  7.97E+00 buck.(SAND);rolling with skin buckl.; M=4;N=1;slope=0.;FS=1.5556



*************** LOAD CASE NO. 2  ****************
***NOTE: Rectangular stringers and IQUICK( 2)=1
Therefore, there will be no alternate buckling solns
for this load case.

****************************************
ITERATION NO., LOAD SET NO., SUBCASE NO. =   0   2   1     PANEL MIDLENGTH
****************************************
```

Table 7 (p.2 of 3)

```
 ANALYSIS: ITYPE=2;  IQUICK=1;  LOAD SET 2;  SUBCASE 1:
 LOADING: Nx, Ny, Nxy, Mx, My =  -8.02E+03 -8.02E-03  4.01E+01  0.00E+00  0.00E+00
          Nxo, Nyo, pressure  =   0.00E+00  1.13E+04 -5.69E+01

 MARGINS FOR CURRENT DESIGN: LOAD CASE NO. 2, SUBCASE NO. 1
 MAR. MARGIN
 NO.  VALUE                 DEFINITION
 1  3.27E+00 Inter-ring bucklng, discrete model, n=13  circ.halfwaves;FS=1.1
 2  1.75E+00 matl=1 ; substiffener effective stressSTRCON MID.;FS=1.2658
 3  6.92E-01 eff.stress:matl=1,SKN,Iseg=2,at:n=6,layer=1,z=-0.2;-MID.;FS=1.2658
 4  6.85E+01 buckling margin stringer Iseg.3 . Local halfwaves=2  .MID.;FS=1.
 5  3.56E+00 buck.(DONL);simp-support smearsubstf; M=2;N=1;slope=0.;FS=1.
 6  8.94E+00 buck.(DONL);simp-support smear rings; M=24;N=1;slope=0.;FS=1.
 7  1.88E+00 buck.(DONL);simp-support general buck;M=3;N=10;slope=0.;FS=1.1
 8  7.17E+00 buck.(DONL);rolling with smearsubstf; M=2;N=1;slope=0.;FS=1.
 9  1.11E+01 buck.(DONL);rolling with smear rings; M=23;N=1;slope=0.;FS=1.
10  7.72E+01 buck.(DONL);rolling only of stringers;M=40;N=0;slope=0.;FS=1.4
11  1.45E+01 buck.(DONL);rolling with skin buckl.; M=4;N=1;slope=0.;FS=1.
12  1.47E+02 buckling:simp-support of substring.M=4;FS=1.
13  5.98E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
14  3.56E+00 buck.(SAND);simp-support smearsubstf; M=2;N=1;slope=0.;FS=1.
15  8.94E+00 buck.(SAND);simp-support smear rings; M=24;N=1;slope=0.;FS=1.
16  1.87E+00 buck.(SAND);simp-support general buck;M=3;N=10;slope=0.;FS=1.1
17  7.17E+00 buck.(SAND);rolling with smearsubstf; M=2;N=1;slope=0.;FS=1.
18  1.11E+01 buck.(SAND);rolling with smear rings; M=23;N=1;slope=0.;FS=1.
19  1.45E+01 buck.(SAND);rolling with skin buckl.; M=4;N=1;slope=0.;FS=1.


 ****************************************
 ITERATION NO., LOAD SET NO., SUBCASE NO. =   0   2   2     AT RINGS
 ****************************************

 ANALYSIS: ITYPE=2;  IQUICK=1;  LOAD SET 2;  SUBCASE 2:
 LOADING: Nx, Ny, Nxy, Mx, My =  -8.02E+03 -8.02E-03  4.01E+01  0.00E+00  0.00E+00
          Nxo, Nyo, pressure  =   0.00E+00  1.13E+04 -5.69E+01

 MARGINS FOR CURRENT DESIGN: LOAD CASE NO. 2, SUBCASE NO. 2
 MAR. MARGIN
 NO.  VALUE                 DEFINITION
 1  3.25E+00 Inter-ring bucklng, discrete model, n=13  circ.halfwaves;FS=1.1
 2  1.80E+00 matl=1 ; substiffener effective stressSTRCON RNGS;FS=1.2658
 3  6.96E-01 eff.stress:matl=1,SKN,Iseg=2,at:n=6,layer=1,z=0.2;-RNGS;FS=1.2658
 4  6.86E+01 buckling margin stringer Iseg.3 . Local halfwaves=2  .RNGS;FS=1.
 5  3.51E+00 buck.(DONL);simp-support smearsubstf; M=2;N=1;slope=0.;FS=1.
 6  8.89E+00 buck.(DONL);simp-support smear rings; M=24;N=1;slope=0.;FS=1.
 7  7.12E+00 buck.(DONL);rolling with smearsubstf; M=2;N=1;slope=0.;FS=1.
 8  1.11E+01 buck.(DONL);rolling with smear rings; M=23;N=1;slope=0.;FS=1.
 9  8.53E+01 buck.(DONL);rolling only of stringers;M=40;N=0;slope=0.;FS=1.4
10  1.44E+01 buck.(DONL);rolling with skin buckl.; M=4;N=1;slope=0.;FS=1.
11  1.61E+02 buckling:simp-support of substring.M=4;FS=1.
12  5.88E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
13  3.51E+00 buck.(SAND);simp-support smearsubstf; M=2;N=1;slope=0.;FS=1.
14  8.89E+00 buck.(SAND);simp-support smear rings; M=24;N=1;slope=0.;FS=1.
15  7.12E+00 buck.(SAND);rolling with smearsubstf; M=2;N=1;slope=0.;FS=1.
16  1.11E+01 buck.(SAND);rolling with smear rings; M=23;N=1;slope=0.;FS=1.
17  1.44E+01 buck.(SAND);rolling with skin buckl.; M=4;N=1;slope=0.;FS=1.
 ***********  ALL 2 LOAD SETS PROCESSED  ***********
 ****************************************************

          SUMMARY OF INFORMATION FROM OPTIMIZATION ANALYSIS
 VAR. DEC. ESCAPE LINK. LINKED  LINKING   LOWER     CURRENT     UPPER       DEFINITION
  NO. VAR.  VAR.  VAR.   TO   CONSTANT   BOUND      VALUE      BOUND
   1   Y     N     N      0    0.00E+00  2.00E+00 1.1363E+01  1.60E+01       B(STR):stiffener s»
pacing, b: STR seg=NA, layer=NA
   2   N     N     Y      1    3.33E-01  0.00E+00 3.7837E+00  0.00E+00      B2(STR):width of st»
ringer base, b2 (must be > 0, see
   3   Y     N     N      0    0.00E+00  6.50E-02 1.8499E+00  1.85E+00       H(STR):height of s»
tiffener (type H for sketch), h:
   4   Y     Y     N      0    0.00E+00  6.50E-02 4.0000E-01  4.00E-01   T(1 )(SKN):thickness f»
or layer index no.(1 ): SKN seg=1
   5   Y     N     N      0    0.00E+00  5.00E-04 7.5899E-02  5.00E+00   TSUB,substr:Thickness, »
TSUB, of substiffener set(1 ): SK
   6   Y     N     N      0    0.00E+00  4.00E-03 6.7252E-02  1.05E+01   HSUB,substr:Height, HSU»
B, of substiffener set(1 ): SKN s
   7   Y     N     N      0    0.00E+00  2.00E-02 5.4041E+00  8.00E+00   BSUB,substr:Spacing, BS»
UB, of substiffener set(1 ): SKN
   8   Y     Y     N      0    0.00E+00  6.50E-02 9.9995E-01  1.00E+00   T(2 )(STR):thickness f»
or layer index no.(2 ): STR seg=3
```

Table 7 (p. 343)

```
   9   Y     N     N      0    0.00E+00  2.00E+00 2.1170E+01  5.00E+01        B(RNG):stiffener s»
pacing, b: RNG seg=NA, layer=NA
  10   N     N     N      0    0.00E+00  0.00E+00 0.0000E+00  0.00E+00       B2(RNG):width of ri»
ng base, b2 (zero is allowed): RN
  11   N     N     Y      3    1.00E+00  0.00E+00 1.8499E+00  0.00E+00        H(RNG):height of s»
tiffener (type H for sketch), h:
  12   Y     Y     N      0    0.00E+00  6.50E-02 1.0000E+00  1.00E+00    T(3 )(RNG):thickness f»
or layer index no.(3 ): RNG seg=3
0
   CURRENT VALUE OF THE OBJECTIVE FUNCTION:
 VAR. STR/ SEG. LAYER   CURRENT
 NO.  RNG  NO.   NO.     VALUE          DEFINITION
            0     0   4.919E+03  WEIGHT OF THE ENTIRE PANEL

  TOTAL WEIGHT OF SKIN                              =   3.0236E+03
  TOTAL WEIGHT OF SUBSTIFFENERS                     =   7.1396E+00
  TOTAL WEIGHT OF STRINGERS                         =   1.2282E+03
  TOTAL WEIGHT OF RINGS                             =   6.6054E+02
  SPECIFIC WEIGHT (WEIGHT/AREA) OF STIFFENED PANEL=   6.3780E-02
 IN ORDER TO AVOID FALSE CONVERGENCE OF THE DESIGN, BE SURE TO
 RUN  PANDAOPT  MANY TIMES DURING AN OPTIMIZATION. INSPECT THE
 allen.OPP  FILE AFTER EACH OPTIMIZATION RUN. OR BETTER YET,
 RUN SUPEROPT.
 ********************* END OF allen.OPM FILE *****************
```

compare w. the 2.704 in Table 11

H(STR)
T(1)(SKN)
T(2)(STR)
T(3)(RNG)
} all at their upper bounds

Only ground buckling is critical. (load set 1)

You need to set higher upper bounds on

Table 8 allen.BEG

```
n              $ Do you want a tutorial session and tutorial output?
 124           $ Panel length normal to the plane of the screen, L1
622.0353       $ Panel length in the plane of the screen, L2
r              $ Identify type of stiffener along L1 (N,T,J,Z,R,A,C,G)
8              $ stiffener spacing, b
0.6670000      $ width of stringer base, b2 (must be > 0, see Help)
6.0000000      $ height of stiffener (type H for sketch), h
n              $ Are the stringers cocured with the skin?
10000          $ 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?
0.6500000E-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)
y              $ Any more layers or groups of layers in Segment no.( 1)
n              $ Is the next group of layers to be a "default group"?
y              $ Does one of the additional layers consist of sub-stiffeners?
n              $ Does this sub-stiffener "layer" form an isogrid?
0              $ Index, NSURF = 0 or 1, for substiffener "layer"( 1)
1              $ Index, NB2 = 0 or 1, for substiffener "layer"( 1)
0.2000000      $ Thickness, TSUB, of substiffener set( 1)
2.0000000      $ Height, HSUB, of substiffener set( 1)
0              $ Angle, THSUB (degrees), of substiffener set( 1)
2              $ Spacing, BSUB, of substiffener set( 1)
1              $ Material type, MATSUB,  for substiffener set( 1)
n              $ Are there any more substiffener sets in substiffener "layer"
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?
0.6500000      $ thickness for layer index no.( 2)
0              $ winding angle (deg.) for layer index no.( 2)
1              $ 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)
8              $ stiffener spacing, b
0              $ width of ring base, b2 (zero is allowed)
4.0000000      $ 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?
0.6500000      $ thickness for layer index no.( 3)
0              $ winding angle (deg.) for layer index no.( 3)
1              $ 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.)?
198            $ 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)?
0.1120000E+08  $ Young's modulus,                E( 1)
0.3000000      $ Poisson's ratio,               NU( 1)
4307692.       $ 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 ?
66000.00       $ Maximum allowable effective stress in material type( 1)
n              $ Do you want to take advantage of "bending overshoot"?
0.9800000E-01  $ weight density (greater than 0!) of material type( 1)
n              $ Is lamina cracking permitted along fibers (type H(elp))?
0              $ Prebuckling: choose 0=bending included; 2=use membrane theory
0              $ Buckling: choose 0=simple support or 1=clamping
```

new → 6.0000000 — was too low (0.65)

new → 1 — was 0

new → 0.2000000 — was 0.05

new → 2.0000000 — was 0.4 (too small)

new → 4.0000000 — was too low (0.65)

Table 9 alben.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,...)
 0.6500000E-01   $ Lower bound of variable no.( 4)
  2.000000       $ Upper bound of variable no.( 4)
      y          $ Any more decision variables (Y or N) ?
         1       $ Choose a decision variable (1,2,3,...)
         2       $ Lower bound of variable no.( 1)
        50       $ Upper bound of variable no.( 1)
      y          $ Any more decision variables (Y or N) ?
         9       $ Choose a decision variable (1,2,3,...)
         2       $ Lower bound of variable no.( 9)
        50       $ Upper bound of variable no.( 9)
      y          $ Any more decision variables (Y or N) ?
         8       $ Choose a decision variable (1,2,3,...)
 0.6500000E-01   $ Lower bound of variable no.( 8)
  3.000000       $ Upper bound of variable no.( 8)
      y          $ Any more decision variables (Y or N) ?
        12       $ Choose a decision variable (1,2,3,...)
 0.6500000E-01   $ Lower bound of variable no.(12)
  3.000000       $ Upper bound of variable no.(12)
      y          $ Any more decision variables (Y or N) ?
         3       $ Choose a decision variable (1,2,3,...)
 0.6500000E-01   $ Lower bound of variable no.( 3)
  10.50000       $ Upper bound of variable no.( 3)
      y          $ Any more decision variables (Y or N) ?
         6       $ Choose a decision variable (1,2,3,...)
         0       $ Lower bound of variable no.( 6)
  10.50000       $ Upper bound of variable no.( 6)
      y          $ Any more decision variables (Y or N) ?
         7       $ Choose a decision variable (1,2,3,...)
         0       $ Lower bound of variable no.( 7)
         8       $ Upper bound of variable no.( 7)
      y          $ Any more decision variables (Y or N) ?
         5       $ Choose a decision variable (1,2,3,...)
         0       $ Lower bound of variable no.( 5)
         5       $ Upper bound of variable no.( 5)
      y          $ Any more decision variables (Y or N) ?
        11       $ Choose a decision variable (1,2,3,...)
 0.6500000E-01   $ Lower bound of variable no.(11)
  10.50000       $ Upper bound of variable no.(11)
      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?
 0.3330000       $ 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?
```

new

was "y"

inequality expression eliminated

2nd linking eliminated

Table 10 alleviate OPT

```
     n        $ Do you want a tutorial session and tutorial output?
  -8025       $ 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?
      1       $ IQUICK = quick analysis indicator (0 or 1)
2.153846      $ Factor of safety for general instability, FSGEN( 1)
1.555556      $ Factor of safety for panel (between rings) instability, FSPAN( 1)
1.555556      $ Minimum load factor for local buckling (Type H for HELP), FSLOC( 1)
1.555556      $ Minimum load factor for stiffener buckling (Type H), FSBSTR( 1)
      1       $ 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       $ Resultant (e.g. lb/in) normal to the plane of screen, Nx0( 1)
      0       $ Resultant (e.g. lb/in) in the plane of the screen,    Ny0( 1)
      1       $ Axial load applied along the (0=neutral plane), (1=panel skin)
      0       $ Uniform applied pressure [positive upward. See H(elp)], p( 1)
      0       $ Out-of-roundness, Wimpg1=(Max.diameter-Min.diam)/4, Wimpg1( 1)
      0       $ Initial buckling modal general imperfection amplitude, Wimpg2( 1)
      0       $ Initial buckling modal inter-ring imperfection amplitude,Wpan( 1)
      0       $ 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)
      0       $ 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 ?
  -8025       $ Resultant (e.g. lb/in) normal to the plane of screen, Nx( 2)
      0       $ Resultant (e.g. lb/in) in the plane of the screen,    Ny( 2)
      0       $ In-plane shear in load set A,                  Nxy( 2)
     n        $ Does the axial load vary in the L2 direction?
      0       $ Applied axial moment resultant (e.g. in-lb/in), Mx( 2)
      0       $ Applied hoop moment resultant (e.g. in-lb/in), My( 2)
     y        $ Want to include effect of transverse shear deformation?
      1       $ IQUICK = quick analysis indicator (0 or 1)
      1       $ Factor of safety for general instability, FSGEN( 2)
      1       $ Factor of safety for panel (between rings) instability, FSPAN( 2)
      1       $ Minimum load factor for local buckling (Type H for HELP), FSLOC( 2)
      1       $ Minimum load factor for stiffener buckling (Type H), FSBSTR( 2)
1.265753      $ Factor of safety for stress, FSSTR( 2)
     y        $ Do you want "flat skin" discretized module for local buckling?
     n        $ Do you want wide-column buckling to constrain the design?
      0       $ Resultant (e.g. lb/in) normal to the plane of screen, Nx0( 2)
11266.20      $ Resultant (e.g. lb/in) in the plane of the screen,    Ny0( 2)
      1       $ Axial load applied along the (0=neutral plane), (1=panel skin)
-56.90000     $ Uniform applied pressure [positive upward. See H(elp)], p( 2)
     n        $ Is the pressure part of Load Set A?
     n        $ Is the pressure hydrostatic (Type H for "HELP")?
      0       $ Choose in-plane immovable (IFREE=0) or movable (IFREE=1) b.c.( 2)
     y        $ Are you feeling well today (type H)?
     n        $ Is there a maximum allowable deflection due to pressure?
      0       $ Out-of-roundness, Wimpg1=(Max.diameter-Min.diam)/4, Wimpg1( 2)
      0       $ Initial buckling modal general imperfection amplitude, Wimpg2( 2)
      0       $ Initial buckling modal inter-ring imperfection amplitude,Wpan( 2)
      0       $ Initial local imperfection amplitude (must be positive), Wloc( 2)
     n        $ Do you want PANDA2 to change imperfection amplitudes (see H(elp))?( 2)
     y        $ Do you want PANDA2 to find the general imperfection shape?( 2)
      0       $ Maximum allowable average axial strain (type H for HELP)( 2)
     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)
      0       $ Index for type of shell theory (0 or 1 or 2), ISAND
     n        $ Does the postbuckling axial wavelength of local buckles change?
     n        $ 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)
     Y        $ Do you want to prevent secondary buckling (mode jumping)?
```

Table 10 (continued)

```
     Y          $ Do you want to use the "alternative" buckling solution?
   1.0
       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)
```

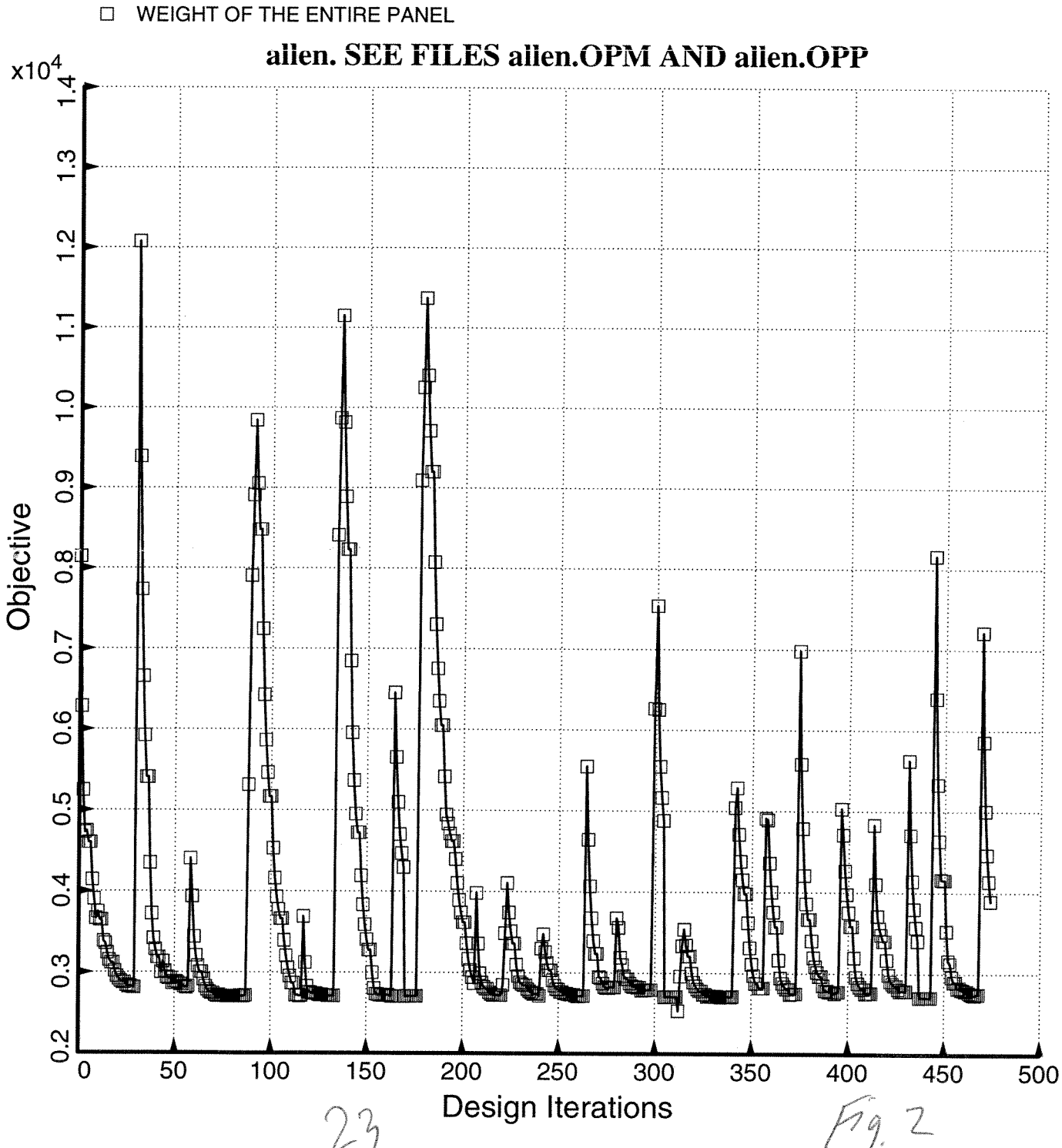
□ WEIGHT OF THE ENTIRE PANEL
allen. SEE FILES allen.OPM AND allen.OPP
x10^4
Objective
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
0
50
100
150
200
250
300
350
400
450
500
Design Iterations

Fig. 2

Table 11 (3 pages) allen.OPM

Abridged allen.OPM file corresponding to the optimum design

```
 ANALYSIS: ITYPE=2;  IQUICK=1;  LOAD SET 1;  SUBCASE 1:
 LOADING: Nx, Ny, Nxy, Mx, My =  -8.02E+03 -8.02E-03  4.01E+01  0.00E+00  0.00E+00
          Nxo, Nyo, pressure  =   0.00E+00  0.00E+00  4.05E-05
  Local buckling load factor from BOSOR4 theory =  1.0000E+17 (flat skin)
0
 MARGINS FOR CURRENT DESIGN: LOAD CASE NO. 1, SUBCASE NO. 1
 MAR. MARGIN
 NO.  VALUE                DEFINITION
 1  5.26E+00 Inter-ring bucklng, discrete model, n=41  circ.halfwaves;FS=1.5556
 2  1.56E+00 matl=1 ; substiffener effective stressSTRCON MID.;FS=1.
 3  1.55E+00 eff.stress:matl=1,STR,Iseg=3,at:TIP,layer=1,z=0.;-MID.;FS=1.
 4  5.35E-03 buckling margin stringer Iseg.3 . Local halfwaves=1  .MID.;FS=1.555
 5  2.74E-03 buck.(DONL);simp-support smearsubstf; M=1;N=1;slope=0.;FS=1.5556
 6 -8.73E-03 buck.(DONL);simp-support smear rings; M=22;N=1;slope=0.;FS=1.5556
 7 -4.38E-02 buck.(DONL);simp-support general buck;M=3;N=7;slope=0.;FS=2.1538
 8  1.41E-02 buck.(DONL);rolling with smearsubstf; M=1;N=1;slope=0.;FS=1.5556
 9 -6.36E-03 buck.(DONL);rolling with smear rings; M=22;N=1;slope=0.;FS=1.5556
10  1.80E+00 buck.(DONL);rolling only of stringers;M=23;N=0;slope=0.;FS=1.4
11  2.78E-02 buck.(DONL);rolling with skin buckl.; M=1;N=1;slope=0.;FS=1.5556
12  2.58E-01 buckling:simp-support of substring.M=1;FS=1.
13  4.35E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
14  2.58E-03 buck.(SAND);simp-support smearsubstf; M=1;N=1;slope=0.;FS=1.5556
15 -8.55E-03 buck.(SAND);simp-support smear rings; M=22;N=1;slope=0.;FS=1.5556
16 -4.61E-02 buck.(SAND);simp-support general buck;M=3;N=7;slope=0.;FS=2.1538
17  1.40E-02 buck.(SAND);rolling with smearsubstf; M=1;N=1;slope=0.;FS=1.5556
18 -6.18E-03 buck.(SAND);rolling with smear rings; M=22;N=1;slope=0.;FS=1.5556
19  2.78E-02 buck.(SAND);rolling with skin buckl.; M=1;N=1;slope=0.;FS=1.5556


 ANALYSIS: ITYPE=2;  IQUICK=1;  LOAD SET 1;  SUBCASE 2:
 LOADING: Nx, Ny, Nxy, Mx, My =  -8.02E+03 -8.02E-03  4.01E+01  0.00E+00  0.00E+00
          Nxo, Nyo, pressure  =   0.00E+00  0.00E+00  4.05E-05
  Local buckling load factor from BOSOR4 theory =  1.0000E+17 (flat skin)
0
 MARGINS FOR CURRENT DESIGN: LOAD CASE NO. 1, SUBCASE NO. 2
 MAR. MARGIN
 NO.  VALUE                DEFINITION
 1  5.26E+00 Inter-ring bucklng, discrete model, n=41  circ.halfwaves;FS=1.5556
 2  1.57E+00 matl=1 ; substiffener effective stressSTRCON RNGS;FS=1.
 3  1.57E+00 eff.stress:matl=1,STR,Iseg=3,at:ROOT,layer=1,z=0.;-RNGS;FS=1.
 4  2.47E-02 buckling margin stringer Iseg.3 . Local halfwaves=1  .RNGS;FS=1.555
 5  2.45E-03 buck.(DONL);simp-support smearsubstf; M=1;N=1;slope=0.;FS=1.5556
 6 -8.99E-03 buck.(DONL);simp-support smear rings; M=22;N=1;slope=0.;FS=1.5556
 7  1.39E-02 buck.(DONL);rolling with smearsubstf; M=1;N=1;slope=0.;FS=1.5556
 8 -6.54E-03 buck.(DONL);rolling with smear rings; M=22;N=1;slope=0.;FS=1.5556
 9  1.83E+00 buck.(DONL);rolling only of stringers;M=23;N=0;slope=0.;FS=1.4
10  2.75E-02 buck.(DONL);rolling with skin buckl.; M=1;N=1;slope=0.;FS=1.5556
11  2.61E-01 buckling:simp-support of substring.M=1;FS=1.
12  4.35E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
13  2.30E-03 buck.(SAND);simp-support smearsubstf; M=1;N=1;slope=0.;FS=1.5556
14 -8.81E-03 buck.(SAND);simp-support smear rings; M=22;N=1;slope=0.;FS=1.5556
15  1.37E-02 buck.(SAND);rolling with smearsubstf; M=1;N=1;slope=0.;FS=1.5556
16 -6.37E-03 buck.(SAND);rolling with smear rings; M=22;N=1;slope=0.;FS=1.5556
17  2.75E-02 buck.(SAND);rolling with skin buckl.; M=1;N=1;slope=0.;FS=1.5556


 ANALYSIS: ITYPE=2;  IQUICK=1;  LOAD SET 2;  SUBCASE 1:
 LOADING: Nx, Ny, Nxy, Mx, My =  -8.02E+03 -8.02E-03  4.01E+01  0.00E+00  0.00E+00
          Nxo, Nyo, pressure  =   0.00E+00  1.13E+04 -5.69E+01
  Local buckling load factor from BOSOR4 theory =  1.0000E+17 (flat skin)
0
 MARGINS FOR CURRENT DESIGN: LOAD CASE NO. 2, SUBCASE NO. 1
 MAR. MARGIN
 NO.  VALUE                DEFINITION
 1  7.99E+00 Inter-ring bucklng, discrete model, n=30  circ.halfwaves;FS=1.1
 2  4.78E-01 matl=1 ; substiffener effective stressSTRCON MID.;FS=1.2658
 3  1.51E-03 eff.stress:matl=1,SKN,Iseg=2,at:n=6,layer=1,z=-0.129;-MID.;FS=1.265
 4  1.89E-01 buckling margin stringer Iseg.3 . Local halfwaves=1  .MID.;FS=1.
 5  7.72E-01 buck.(DONL);simp-support smearsubstf; M=1;N=1;slope=0.;FS=1.
 6  6.48E-01 buck.(DONL);simp-support smear rings; M=22;N=1;slope=0.;FS=1.
 7  1.10E+00 buck.(DONL);simp-support general buck;M=3;N=6;slope=0.;FS=1.1
 8  8.45E-01 buck.(DONL);rolling with smearsubstf; M=1;N=1;slope=0.;FS=1.
 9  6.49E-01 buck.(DONL);rolling with smear rings; M=22;N=1;slope=0.;FS=1.
10  1.52E+00 buck.(DONL);rolling only of stringers;M=23;N=0;slope=0.;FS=1.4
```

Table 11, p. 2 of 3

```
11  1.52E+00 buck.(DONL);rolling with skin buckl.; M=2;N=1;slope=0.;FS=1.
12  2.52E-03 buckling:simp-support of substring.M=2;FS=1.
13  3.20E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
14  7.71E-01 buck.(SAND);simp-support smearsubstf; M=1;N=1;slope=0.;FS=1.
15  6.48E-01 buck.(SAND);simp-support smear rings; M=22;N=1;slope=0.;FS=1.
16  1.09E+00 buck.(SAND);simp-support general buck;M=3;N=6;slope=0.;FS=1.1
17  8.44E-01 buck.(SAND);rolling with smearsubstf; M=1;N=1;slope=0.;FS=1.
18  6.49E-01 buck.(SAND);rolling with smear rings; M=22;N=1;slope=0.;FS=1.
19  1.52E+00 buck.(SAND);rolling with skin buckl.; M=2;N=1;slope=0.;FS=1.


 ANALYSIS: ITYPE=2;  IQUICK=1;  LOAD SET 2;  SUBCASE 2:
 LOADING: Nx, Ny, Nxy, Mx, My =  -8.02E+03 -8.02E-03  4.01E+01  0.00E+00  0.00E+00
          Nxo, Nyo, pressure  =   0.00E+00  1.13E+04 -5.69E+01
  Local buckling load factor from BOSOR4 theory =  1.0000E+17 (flat skin)
0
 MARGINS FOR CURRENT DESIGN: LOAD CASE NO. 2, SUBCASE NO. 2
 MAR. MARGIN
 NO.  VALUE                DEFINITION
 1  7.99E+00 Inter-ring bucklng, discrete model, n=30  circ.halfwaves;FS=1.1
 2  4.97E-01 matl=1 ; substiffener effective stressSTRCON RNGS;FS=1.2658
 3  1.67E-04 eff.stress:matl=1,SKN,Iseg=2,at:n=6,layer=1,z=0.129;-RNGS;FS=1.2658
 4  2.91E-01 buckling margin stringer Iseg.3 . Local halfwaves=1  .RNGS;FS=1.
 5  7.70E-01 buck.(DONL);simp-support smearsubstf; M=1;N=1;slope=0.;FS=1.
 6  6.46E-01 buck.(DONL);simp-support smear rings; M=22;N=1;slope=0.;FS=1.
 7  8.44E-01 buck.(DONL);rolling with smearsubstf; M=1;N=1;slope=0.;FS=1.
 8  6.47E-01 buck.(DONL);rolling with smear rings; M=22;N=1;slope=0.;FS=1.
 9  1.57E+00 buck.(DONL);rolling only of stringers;M=23;N=0;slope=0.;FS=1.4
10  1.52E+00 buck.(DONL);rolling with skin buckl.; M=2;N=1;slope=0.;FS=1.
11  1.77E-02 buckling:simp-support of substring.M=2;FS=1.
12  3.20E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
13  7.69E-01 buck.(SAND);simp-support smearsubstf; M=1;N=1;slope=0.;FS=1.
14  6.46E-01 buck.(SAND);simp-support smear rings; M=22;N=1;slope=0.;FS=1.
15  8.43E-01 buck.(SAND);rolling with smearsubstf; M=1;N=1;slope=0.;FS=1.
16  6.48E-01 buck.(SAND);rolling with smear rings; M=22;N=1;slope=0.;FS=1.
17  1.52E+00 buck.(SAND);rolling with skin buckl.; M=2;N=1;slope=0.;FS=1.
 ***********  ALL 2 LOAD SETS PROCESSED  ***********
 ********************************************************


          SUMMARY OF INFORMATION FROM OPTIMIZATION ANALYSIS
 VAR. DEC. ESCAPE LINK. LINKED  LINKING   LOWER     CURRENT     UPPER        DEFINITION
  NO. VAR.  VAR.  VAR.    TO   CONSTANT   BOUND      VALUE      BOUND
   1   Y     N     N      0    0.00E+00  2.00E+00 2.7559E+01  5.00E+01        B(STR):stiffener s»
pacing, b: STR seg=NA, layer=NA
   2   N     N     Y      1    3.33E-01  0.00E+00 9.1771E+00  0.00E+00       B2(STR):width of st»
ringer base, b2 (must be > 0, see
   3   Y     N     N      0    0.00E+00  6.50E-02 3.3545E+00  1.05E+01        H(STR):height of s»
tiffener (type H for sketch), h:
   4   Y     Y     N      0    0.00E+00  6.50E-02 2.5801E-01  2.00E+00    T(1 )(SKN):thickness f»
or layer index no.(1 ): SKN seg=1
   5   Y     N     N      0    0.00E+00  2.00E-03 1.0122E-01  5.00E+00   TSUB,substr:Thickness, »
TSUB, of substiffener set(1 ): SK
   6   Y     N     N      0    0.00E+00  2.00E-02 1.1794E+00  1.05E+01   HSUB,substr:Height, HSU»
B, of substiffener set(1 ): SKN s
   7   Y     N     N      0    0.00E+00  2.00E-02 8.0000E+00  8.00E+00   BSUB,substr:Spacing, BS»
UB, of substiffener set(1 ): SKN
   8   Y     Y     N      0    0.00E+00  6.50E-02 2.9317E-01  3.00E+00    T(2 )(STR):thickness f»
or layer index no.(2 ): STR seg=3
   9   Y     N     N      0    0.00E+00  2.00E+00 1.0444E+01  5.00E+01        B(RNG):stiffener s»
pacing, b: RNG seg=NA, layer=NA
  10   N     N     N      0    0.00E+00  0.00E+00 0.0000E+00  0.00E+00       B2(RNG):width of ri»
ng base, b2 (zero is allowed): RN
  11   Y     N     N      0    0.00E+00  6.50E-02 7.8782E+00  1.05E+01        H(RNG):height of s»
tiffener (type H for sketch), h:
  12   Y     Y     N      0    0.00E+00  6.50E-02 6.5000E-02  3.00E+00    T(3 )(RNG):thickness f»
or layer index no.(3 ): RNG seg=3
0
   CURRENT VALUE OF THE OBJECTIVE FUNCTION:
 VAR. STR/ SEG. LAYER   CURRENT
 NO.  RNG  NO.   NO.     VALUE                DEFINITION
            0     0  2.704E+03  WEIGHT OF THE ENTIRE PANEL

  TOTAL WEIGHT OF SKIN                                =   1.9503E+03
  TOTAL WEIGHT OF SUBSTIFFENERS                       =   1.1279E+02
  TOTAL WEIGHT OF STRINGERS                           =   2.6975E+02
  TOTAL WEIGHT OF RINGS                               =   3.7064E+02
  SPECIFIC WEIGHT (WEIGHT/AREA) OF STIFFENED PANEL=   3.5050E-02
```

Compare with 4.919 in Table 7

Table 11, p. 3 of 3

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IN ORDER TO AVOID FALSE CONVERGENCE OF THE DESIGN, BE SURE TO
RUN  PANDAOPT  MANY TIMES DURING AN OPTIMIZATION. INSPECT THE
allen.OPP  FILE AFTER EACH OPTIMIZATION RUN. OR BETTER YET,
RUN SUPEROPT.
********************* END OF allen.OPM FILE *****************
```

Notice that many more margins are critical than in Table 7.