February 28, 2011

PANDA2 RUN STREAM STARTING FROM SCRATCH

Commands from the user are in **16 pt bold face**. Note: the string, **“bush->”**, is not part of the command typed by the user.

Optimization of an aluminum hydrostatically compressed cylindrical shell with T-shaped stringers and T-shaped rings

The user-provided name of the case is: **cylstif**

INTRODUCTION

This file is long because in it are described not only executions of PANDA2 but also executions of BIGBOSOR4 and STAGS. BIGBOSOR4, a shell-of-revolution analyzer, and STAGS, a general-purpose code, are used to verify PANDA2 predictions for the T-stringer and T-ring stiffened cylindrical shell optimized by PANDA2. PANDA2 has processors, PANEL and PANEL2, which produce valid input files for BIGBOSOR4, and STAGSUNIT, which produces valid input files for STAGS. The example, a hydrostatically compressed cylindrical shell with T-shaped stringers and with T-shaped rings, is complex. The optimized design exhibits many different kinds of buckling: general buckling, inter-ring buckling, local buckling, as well as various types of buckling of the T-shaped stringers and T-shaped rings.

SUMMARY

This report consists of three parts:

PART 1.0;
First, we find from PANDA2 an optimum design of an imperfect T-stringer and T-ring stiffened cylindrical shell made of aluminum. The T-stiffened cylindrical shell is 300 inches long and has a radius of 100 inches. The T-stringers are external and the T-rings are internal. The loading is uniform axial compression, Nx = p x r/2, and uniform circumferential compression, Ny = p x r, in which p is the uniform external pressure. The imperfection is in the form of the general buckling mode. After we find an optimum design via two executions of the PANDA2 processor called SUPEROPT, we obtain predictions for that same optimum design from an analysis in which the amplitude of the general buckling modal imperfection is set equal to zero.

PART 2.0:
Second, we use the PANDA2 processors, PANEL and PANEL2, to set up BIGBOSOR4 models, then run BIGBOSOR4 and compare results with the predictions from PANDA2 for the optimized design. The shell is perfect.

PART 3.0:
Third, we use the PANDA2 processor, STAGSUNIT, to set up STAGS models, then compare the results from STAGS with predictions from BIGBOSOR4 and PANDA2 for the optimized design. The shell is perfect.

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***************************************************
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****
PART 1.0: Processing with PANDA2
****

PART 1.1: Activate the PANDA2 commands

bush-> panda2log

PANDA2 commands have been activated.

```
PANDA2 commands are:
begin      - you provide a starting design, material properties, boundary conditions
choosetemp - choose temparature dependence
setup      - PANDA2 generates BOSOR4-type matrix skylines for use by PANDA2
decide     - you choose decision variables, lower and upper bounds, linking relationships
mainsetup  - you provide loading, imperfection amplitudes, fact.of safety, analysis type, strategy
pandaopt   - launch run of mainprocessor for a single set of design iterations
superopt   - launch run for multiple sets of design iterations (obtain a global optimum design)
change     - assign new values to parameters (or save an optimum design)
autochange - assign new vector of decision variables randomly (used in the superopt process)
chooseplot - choose which variables/margins to plot
diplot     - generate & print PostScript file containing plots
panel      - generate BOSOR4 input for a skin-stringer multi-module model
panel2     - generate BOSOR4 input for a skin-ring multi-module model
panel3     - generate BOSOR4 input for a skin-stringer + weld land multi-module model
stagsmodel - generate STAGS input for panel (element unit, no rings)
stagsunit  - generate STAGS input for panel (shell units, both rings and stringers permitted)
cleanpan   - delete temporary case-specific files
```

```
 A typical PANDA2 runstream is:
   begin
   setup
   decide
   mainsetup
   superopt  (or pandaopt)
   (several more pandaopts if the previous command is not superopt)
   chooseplot
   diplot
   change
   superopt or pandaopt
   etc.
   cleanpan
```

Please consult the files in .../panda2/doc for more information about PANDA2.
Also review the sample cases in .../panda2/case.
Also read the published papers listed in the file .../panda2/doc/panda2.ref.
The file, .../panda2/doc/panda2.news contains updates and comments since 1987.
Useful annotation appears in the *.OPM file when NPRINT = 2 in the *.OPT file.

USEFUL HINT PERTAINING TO THE INTERACTIVE INPUT YOU SHOULD PROVIDE DURING 'mainsetup':
After you type the command, 'mainsetup', try just hitting ENTER to obtain the default value of any data entry that you are unsure about. PANDA2 will provide what its developer usually chooses. Generally use 5 iterations/pandaopt; Generally use NPRINT = 0; Generally use 'superopt'; Generally choose 5 pandaopts per autochange for superopt runs.

USEFUL HINT FOR SAVING OPTIMUM DESIGNS FOR FUTURE RUNS:
Once you have obtained a global optimum design that you are happy with, execute the process called 'change' in order to save this global optimum design in a file called *.CHG
Then the global optimum design will be preserved in the *.CHG file after execution of 'cleanpan'.
You can then execute 'change' immediately following 'begin' in order to re-establish that same global optimum design at any time in the future.

```
FILES THAT ARE PRESERVED FOLLOWING EXECUTION OF THE COMMAND, 'cleanpan':
 *.BEG (from 'begin'), *.DEC (from 'decide'), *.OPT (from 'mainsetup'), *.CHG (from 'change')
 *.CPL (from 'chooseplot'), *.PAN (from 'panel' or 'panel2'), *.STG (from 'stagsunit'
 or from 'stagsmodel'). These preserved files are valid input for the interactive processors,
 begin, decide, mainsetup, change, chooseplot, panel or panel2, stagsunit or stagsmodel,
 respectively.
```

PART 1.2: Execute the PANDA2 processor called "BEGIN" in order to establish a starting design, material properties, boundary conditions.

bush-> begin

```
Please enter PANDA2 case name: cylstif


 ****************   BEGIN   ******************

 Purpose of BEGIN is to permit you to provide a starting design
 in an interactive mode. You give starting dimensions, material
 properties, allowables. The interactive session is stored on a
 file called cylstif.BEG, in which cylstif is a name that you have
 chosen for the case.(cylstif must remain the same as you use all
 the PANDA2 processors.)  In future runs of the same or a
 slightly modified case, you will find it convenient to use the
 file cylstif.BEG as input.  Rather than answer all the questions
 interactively, you can use cylstif.BEG or an edited version of
 cylstif.BEG as input to BEGIN.  BEGIN also generates an output
 file called cylstif.OPB. cylstif.OPB lists a summary of the case,
 and if you choose the tutorial option, the questions, helps,
 and your answers for each input datum.

 ************************************************

 Are you correcting, adding to, or using an existing file?=n
 n
 Do you want a tutorial session and tutorial output?=n
 n

 Now you start to provide input data. You will be prompted by
 short questions. If you need help, just type H as an
 answer to the prompt instead of the datum called for. In most
 instances you will then be given more information on the datum
 you must provide. It may be a good idea to run the tutorial
 option if you are a new user of PANDA2.

 Overall panel dimensions:
   1. length normal to the plane of the screen, L1
   2. length in the plane of the screen,        L2

 SOME ADVICE ON MODELING WHEN NORMAL PRESSURE IS PRESENT:
 If you are designing a panel that has both stringers and rather
 large rings, and you expect that in the prebuckling phase there
 may be significant bending between these large rings due to the
 pressure, then set up models in which there are stringers only,
 or stringers and weak rings. ("weak" implies that the normal
 pressure does not cause significant local axial bending between
 them.) The entire axial length of each model must be equal to the
 spacing of the large rings. The boundary conditions along the
 edges where the large rings are supposed to be should be clamped
 for the prebuckling phase and simply supported for the buckling
 phase of the analysis if the stringers are not tapered in the
```

neighborhoods of the large rings. If the stringers are tapered near the large rings, then use simple support for both the prebuckling and the buckling phases of the analysis.

Panel length normal to the plane of the screen, L1=h

This is the axial length of the panel. For a cylindrical panel, this is the length of the generator of the panel. This is the x - direction.

Panel length normal to the plane of the screen, L1=300
      300
Panel length in the plane of the screen, L2=h

For a cylindrical panel, this is the arc length along the circumference of the entire panel. A complete cylindrical shell can be modelled by using L2 = pi*radius. Then the number of half-waves over this circumferential length is the same as the number of full waves around the complete 360 degree circumference. If you are analyzing a complete cylindrical shell, especially one with loads that vary around the circumference, it will probably be best to divide it into panels. Then analyze the panel as a structure subjected to multiple sets of uniform loads. (See the paper, PANDA2--program for minimum weight design of stiffened, composite, locally buckled panels, for an example. Computers and Structures, Vol. 25, pp 570-574, Fig. 79)

Panel length in the plane of the screen, L2=314.16
  314.1600

The stiffened panel is considered to be divided into several identical modules, as follows:

```
         ___                     ___                    ___
          |                       |                      |
          |                       |                      |
--------=====--------------------=====------------------=====---------
|<---Module No. 1-->|<-- Module No. 2 --->|<--- Module No. 3 -->|
```

For a module you will be asked to provide the following data:
   1. width, b, of the module (same as stiffener spacing)
   2. width, b2, of the thickened region at the base of the stiffener (shown as ====== above).
   3. height, h, of the stiffener
   4. width, w, of the outstanding flange of the stiffener, if any
   5. number of unique segments in the module (4 in above figure)
   6. For each unique segment of the module:
      - 6.1 number of layers thru thickness
      - 6.2 layer type indicator for each layer
      - 6.3 For each new layer type:
        - 6.3.1 thickness
        - 6.3.2 winding angle (which means layup angle)
        - 6.3.3 material type indicator

Identify type of stiffener along L1 (N,T,J,Z,R,A,C,G)=h

L1 is the length of the panel normal to the plane of the screen.
For choice "G" (isoGrid) L1 is irrelevant.

N = no stiffeners along L1 at all
T = T-shaped cross section
J = J-shaped cross section (or angle with flange away from skin)
Z = Z-shaped cross section with riveted faying flange
R = rectangular cross section (blade stiffener)
A = hat-shaped or trapezoidal cross section (enclosing area)

```
C = Truss-core sandwich construction (added July 1989)
G = isoGrid (added September 1992). With isoGrid the stiffeners
    can be T-shaped, J-shaped, or rectangular (blade).

Identify type of stiffener along L1 (N,T,J,Z,R,A,C,G)=t
t

Module with T-shaped stiffener...

  Seg. No. 4-.
             . |<------  w  ------>|
              .____________________
                         |   ^
     Segment No. 3 -----> |   |
                         |   |
         Seg. No. 2-.    |   h
                    .    |   |
   Seg. No. 1-.      .   |   |             .-Seg. No. 5
            .         .  |   V            . (same as Seg. 1)
  -------------==================------------
               |<------ b2 ------->|
  |<--- Module width  =  stiffener spacing, b --->|

stiffener spacing, b=h
 There is no more help. Do your best.
stiffener spacing, b=30
       30
width of stringer base, b2 (must be > 0, see Help)=h

Width b2 must be greater than zero.  In fact, it should always
be greater than a tenth of the module width, b. This segment of
the module is considered by PANDA2 to consist of the skin plus
the faying flange, if any, of the stiffener. In the PANDA2
model b2 must be greater than about a tenth of the total module
width, b, because the section of width b2 is considered to be
a separate segment which is discretized. If you make b2 too
small, numerical difficulties might occur.

If the panel skin in the width b2 has the SAME CONSTRUCTION
as that outside this region, set b2 to a value about b/3. IN
THIS CASE, IN "DECIDE" MAKE SURE TO LINK THE WIDTH OF b2 TO
THE SPACING, b:
                  b2 = C*b

IN WHICH  C  IS THE LINKING CONSTANT.  (SET C = APPROXIMATELY 0.3)

width of stringer base, b2 (must be > 0, see Help)=10.
  10.00000
height of stiffener (type H for sketch), h=h

The height of the stiffener is measured from the surface of
the stiffener base to the middle surface of the stiffener flange,
as shown in the sketch below:

                     ----------------
                     - - - - - - - - - - - <--middle surface of
 stiffener flange--->----------------   ^     flange material
                            | |         |
                            | |         |
       stiffener web-----> | |         h = stiffener height
                            | |         |
                            | |         |    .-stiffener base
                            | |         V   .
```

```
              ------------------------------      .-panel skin
             |<---width of stiffener base-->|    .
--------------                              ---------------
--------------                              ---------------
             |                              |
              ------------------------------

height of stiffener (type H for sketch), h=10.
  10.00000
width of outstanding flange of stiffener, w=h
 There is no more help. Do your best.
width of outstanding flange of stiffener, w=10.
  10.00000
Are the stringers cocured with the skin?=h

Stringers and skin may be cured separately, then glued
together at room temperature, or they may be cocured. Which
method is used very much affects the residual stresses and
residual deformations of the panel. The residual stresses
and deformations in cocured panels are caused by the different
thermal expansion properties of the stringers and skin as the
panel cools down from the curing temperature to room tempera-
ture. If this is not a composite panel, the answer here should
probably be N.

Are the stringers cocured with the skin?=n
n
What force/(axial length) will cause web peel-off?=h

Irrelevant for ISOGRID configuration.

Wanted here is the force-per-axial-length of stringer required
to peel half of each stringer web and faying flange away from the
panel skin. "Half the stringer web" means half of the thickness.
It is assumed that each half of the stringer web consists of
layers that start as part or all of the faying flange on either
side of the stiffener. These layers "turn a corner" to become
the stringer web. Tensile forces in the plane of the web,
normal to the stringer axis, will therefore tend to peel the
web halves from the faying flanges from which they derive.
In the post-local buckling regime, such forces develop in each
stringer web. These are calculated by PANDA2, and a constraint
condition is formulated that indicates whether or not stringer
popoff will occur because of web-peel-off caused by post-local
buckling deformations. The force required here depends on what
sort of adhesive is used between stringers and skin and its
thickness.  You will probably have to consult peel test data for
this input datum.  Units required are force/length.  A typical
value for graphite-epoxy is in the range 40-100 lb/in. Figures
5 and 6 of the paper, ``PANDA2--program for minimum weight
design of stiffened, composite, locally buckled panels" show
the phenomenon just described and a peel-test specimen.  Figure
7 is a photograph of a graphite-epoxy peel test specimen after
failure.

What force/(axial length) will cause web peel-off?=1000000.
  1000000.

Now you will be asked to provide properties for the panel
module on a segment-by-segment basis, starting with the
skin, which is Segment 1, as shown in the Figure above.
In each segment of the module, the wall is considered to be
divided into groups of layers. There are two types of groups:
 1. default groups (12 layers, [90,0,45,-45,0,90]s, all of the
```

    same material and initially all of the same thickness.
    If you choose this option, winding angles cannot be decision
    variables. Thicknesses can be decision variables.);
 2. just plain groups (any number of layers, any winding angles,
    any variety of material types and any variety of thickness.
    Winding angles CAN be decision variables.)
For each default group (group type 1) you will be asked to give:
 1. the thickness of one of the layers;
 2. the material type.
For each "just plain group" (group type 2) you must provide:
 1. the number of layers through the thickness of the group
 2. whether the winding angles can ever be decision variables
 3. layer indices for each layer
 4. whether the layer is a new type of layer
 5. if it is a new type of layer: thickness, winding angle,
    and material type corresponding to that layer index.

Is the next group of layers to be a "default group" (12 layers!)?=n
n

Module with T-shaped stiffener...

```
  Seg. No. 4-.
              . |<------  w  ------>|
               .______________________
                          |   ^
    Segment No. 3 ----->  |   |
                          |   |
        Seg. No. 2-.      |   h
                    .     |   |
   Seg. No. 1-.      .    |   |             .-Seg. No. 5
             .        .   |   V            . (same as Seg. 1)
  --------------=====================================------------
                |<------ b2 ------->|
  |<--- Module width  =  stiffener spacing, b --->|
```

number of layers in the next group in Segment no.(1)=1
        1
Can winding (layup) angles ever be decision variables?=h

The term "winding angle" is used throughout PANDA2. However,
PANDA2 assumes that the composite laminates are "laid up"
layer by layer, with each layer having a distinct and constant
angle between the axial direction (normal to the screen) and
the direction of the fibers (high modulus direction). Hence,
the composite structure is not wound but built up
layer by layer. Fig. 2 of the journal article on PANDA shows
the geometry. (See the article, "PANDA--interactive program
for minimum weight design of stiffened cylindrical panels and
shells", Computers and Structures, vol 16, pp 167-185, 1983)

Use with caution. Please note that weight does not change with
winding angle, so that if you plan to optimize something and
allow winding angles to be decision variables, you must also allow
the thickness of at least one layer also to be a decision variable.

Also, any decision variable that is zero or that becomes zero during
design iterations is dropped by PANDA2 from the list of decision
variables: It ceases being a decision variable from that moment on.
Hence, if you specify that the winding angle of a layer is a decision
variable, and if you also specify that the winding angle of this
layer is zero, this layer winding angle will not be a decision
variable during optimization cycles. If you really want the layer
winding angle to be a decision variable, set it initially to 5 or 10

```
degrees or use CHANGE to change it from zero to 5 or 10 degrees.

Can winding (layup) angles ever be decision variables?=n
n
layer index (1,2,...), for layer no.( 1)=h

A layer index implies the following "bundle" of properties:

   1. thickness of the layer
   2. winding (layup) angle of the layer (degrees between the
      normal to the screen and the direction in which the
      modulus E1 (fiber direction) is measured)
   3. material type of the layer

The three properties just listed are identical in two different
layers if both of these layers have the same layer index.

layer index (1,2,...), for layer no.( 1)=1
        1
Is this a new layer type?=h
 There is no more help. Do your best.
Is this a new layer type?=y
y

thickness, winding angle, material for layer index

thickness for layer index no.( 1)=.1
 0.1000000
winding angle (deg.) for layer index no.( 1)=0
        0
material index (1,2,...) for layer index no.( 1)=h

What is required here is an integer. This integer is a pointer
to a material, the properties of which will be asked of you
later. The integer must be greater than or equal to 1   .

material index (1,2,...) for layer index no.( 1)=1
        1

Module with T-shaped stiffener...

  Seg. No. 4-.
            . |<------  w  ------>|
             .______________________
                        |   ^
     Segment No. 3 ----->   |   |
                        |   |
         Seg. No. 2-.   |   h
                   .    |   |
   Seg. No. 1-.      .  |   |             .-Seg. No. 5
            .         . |   V            . (same as Seg. 1)
  -------------------------------------------------
              |<------ b2 ------->|
  |<--- Module width  =  stiffener spacing, b --->|

Any more layers or groups of layers in Segment no.( 1)=n
n

Module with T-shaped stiffener...

  Seg. No. 4-.
            . |<------  w  ------>|
             .______________________
                        |   ^
```

```
      Segment No. 3 -----> |    |
                           |    |
          Seg. No. 2-.     |    h
                     .     |    |
    Seg. No. 1-.      .    |    |             .-Seg. No. 5
              .        .   |    V            . (same as Seg. 1)
  -------------------------=========================--------
                |<------ b2 ------->|
  |<--- Module width  =  stiffener spacing, b --->|
```

```
Next, provide the properties of Segment 2, which is the
base under the stiffener.  This base includes the skin
under the stiffener plus the stiffener flange that fays with
the skin, except in the case of a hat with b2 = w2, for which
the "base" is simply the laminate under the hat.

***** IMPORTANT NOTE *****

At least one of the layers in Segment 2 should ordinarily be
the same as one of the layers in Segment 1. If Segment 2
represents a thickened region under the stiffener, model it as
being composed of the layers in Segment 1 plus additional layer(s).
NOTE: There is an exception when the user wants to take advantage
of "bending overshoot" in stress constraints. For details, see
ITEM No. 299 in ...panda2/doc/panda2.news and read carefully
messages printed to the screen during the input session.

**** END OF IMPORTANT NOTE *****

Is the next group of layers to be a "default group" (12 layers!)?=n
n
number of layers in the next group in Segment no.( 2)=1
        1
Can winding (layup) angles ever be decision variables?=n
n
layer index (1,2,...), for layer no.( 1)=1
        1
Is this a new layer type?=n
n
Any more layers or groups of layers in Segment no.( 2)=n
n

Module with T-shaped stiffener...
```

```
  Seg. No. 4-.
             . |<------  w  ------>|
              .____________________
                           |    ^
      Segment No. 3 -----> |    |
                           |    |
          Seg. No. 2-.     |    h
                     .     |    |
    Seg. No. 1-.      .    |    |             .-Seg. No. 5
              .        .   |    V            . (same as Seg. 1)
  -------------------------=========================--------
                |<------ b2 ------->|
  |<--- Module width  =  stiffener spacing, b --->|
```

```
Next, provide the properties of Segment 3    3    3    3    3...

Is the next group of layers to be a "default group" (12 layers!)?=n
n
```

```
number of layers in the next group in Segment no.( 3)=1
        1
Can winding (layup) angles ever be decision variables?=n
n
layer index (1,2,...), for layer no.( 1)=2
        2
Is this a new layer type?=y
y

thickness, winding angle, material for layer index

thickness for layer index no.( 2)=.1
 0.1000000
winding angle (deg.) for layer index no.( 2)=0
        0
material index (1,2,...) for layer index no.( 2)=1
        1
Any more layers or groups of layers in Segment no.( 3)=n
n

Module with T-shaped stiffener...

  Seg. No. 4-.
             . |<------  w  ------>|
              .____________________
                          |   ^
     Segment No. 3 ----->  |   |
                          |   |
         Seg. No. 2-.     |   h
                     .    |   |
   Seg. No. 1-.       .   |   |              .-Seg. No. 5
             .         .  |   V             . (same as Seg. 1)
  --------------=================================-----------
               |<------ b2 ------->|
  |<--- Module width  =  stiffener spacing, b --->|


Next, provide the properties of Segment 4    4    4    4    4...

Is the next group of layers to be a "default group" (12 layers!)?=n
n
number of layers in the next group in Segment no.( 4)=1
        1
Can winding (layup) angles ever be decision variables?=n
n
layer index (1,2,...), for layer no.( 1)=3
        3
Is this a new layer type?=y
y

thickness, winding angle, material for layer index

thickness for layer index no.( 3)=.1
 0.1000000
winding angle (deg.) for layer index no.( 3)=0
        0
material index (1,2,...) for layer index no.( 3)=1
        1
Any more layers or groups of layers in Segment no.( 4)=n
n
choose external (0) or internal (1) stringers=h

If the panel is flat, choose "external" (0).
```

```
If the panel is cylindrical, choose either 0 or 1.
See Fig. 8, p. 490, of the long 1987 PANDA2 paper for geometry.
If you choose 0 ("external"), then the radius of curvature of the
panel will be regarded as positive. (Referring to the sketch of the
single panel module, the concave surface of the panel skin will be
the bottom surface.)  If you choose 1 ("internal)", then the radius
of curvature of the panel will be regarded as negative. (The bottom
surface in the panel module sketch will be convex.)

choose external (0) or internal (1) stringers=0
        0

Next, you will be asked to provide input data for stiffeners
along the length L2, where L2 is the arc length of the panel in
the plane of the screen.

Identify type of stiffener along L2  (N, T, J, Z, R, A)=t
t

Module with T-shaped stiffener...

  Seg. No. 4-.
            . |<------  w  ------>|
             .______________________
                          |   ^
     Segment No. 3 -----> |   |
                          |   |
         Seg. No. 2-.     |   h
                     .    |   |
   Seg. No. 1-.       .   |   |             .-Seg. No. 5
            .          .  |   V            . (same as Seg. 1)
  --------------==================================-----------
              |<------ b2 ------->|
  |<--- Module width  =  stiffener spacing, b --->|

stiffener spacing, b=50.
  50.00000
width of ring base, b2 (zero is allowed)=0
        0
height of stiffener (type H for sketch), h=h

The height of the stiffener is measured from the surface of
the stiffener base to the middle surface of the stiffener flange,
as shown in the sketch below:

                     ----------------
                     - - - - - - - - - - - <--middle surface of
 stiffener flange--->----------------   ^     flange material
                            | |         |
                            | |         |
        stiffener web-----> | |         h = stiffener height
                            | |         |
                            | |         |    .-stiffener base
                            | |         V   .
             ------------------------------      .-panel skin
            |<---width of stiffener base-->|    .
--------------                              ---------------
--------------                              ---------------
            |                              |
             ------------------------------

height of stiffener (type H for sketch), h=10.
  10.00000
```

```
width of outstanding flange of stiffener, w=10.
  10.00000
Are the rings cocured with the skin?=n
n

Module with T-shaped stiffener...

  Seg. No. 4-.
             . |<------  w  ------>|
              .____________________
                          |    ^
     Segment No. 3 ----->  |    |
                          |    |
         Seg. No. 2-.      |    h
                     .    |    |
   Seg. No. 1-.       .   |    |             .-Seg. No. 5
            .          .  |    V            . (same as Seg. 1)
  -------------------------------------------------
                |<------ b2 ------->|
  |<--- Module width  =  stiffener spacing, b --->|


Next, provide the properties of Segment 3    3    3    3    3...

Is the next group of layers to be a "default group" (12 layers!)?=n
n
number of layers in the next group in Segment no.( 3)=1
        1
Can winding (layup) angles ever be decision variables?=n
n
layer index (1,2,...), for layer no.( 1)=4
        4
Is this a new layer type?=y
y

thickness, winding angle, material for layer index

thickness for layer index no.( 4)=.1
 0.1000000
winding angle (deg.) for layer index no.( 4)=0
        0
material index (1,2,...) for layer index no.( 4)=1
        1
Any more layers or groups of layers in Segment no.( 3)=n
n

Module with T-shaped stiffener...

  Seg. No. 4-.
             . |<------  w  ------>|
              .____________________
                          |    ^
     Segment No. 3 ----->  |    |
                          |    |
         Seg. No. 2-.      |    h
                     .    |    |
   Seg. No. 1-.       .   |    |             .-Seg. No. 5
            .          .  |    V            . (same as Seg. 1)
  -------------------------------------------------
                |<------ b2 ------->|
  |<--- Module width  =  stiffener spacing, b --->|


Next, provide the properties of Segment 4    4    4    4    4...
```

```
Is the next group of layers to be a "default group" (12 layers!)?=n
n
number of layers in the next group in Segment no.( 4)=1
        1
Can winding (layup) angles ever be decision variables?=n
n
layer index (1,2,...), for layer no.( 1)=5
        5
Is this a new layer type?=y
y

thickness, winding angle, material for layer index

thickness for layer index no.( 5)=.1
 0.1000000
winding angle (deg.) for layer index no.( 5)=0
        0
material index (1,2,...) for layer index no.( 5)=1
        1
Any more layers or groups of layers in Segment no.( 4)=n
n
choose external (0) or internal (1) rings=h

The "HELP" comment given for the stringers or isogrid does not
apply here.

   a. If there are stringers, the ring cross section will lie
      above the panel skin if the rings are on the same side
      of the skin as the stringers. If stringers and rings are
      on opposite sides of the skin, the ring cross section will
      lie below the panel skin.

If the panel is cylindrical:
   b. If there are no stringers, the radius of curvature will be
      positive, that is, the concave surface of the panel skin
      will be the bottom surface. (See panel module sketch).

   c. If there are stringers, the sign of the panel curvature is
      governed by whether they are external or internal, and the
      location of the ring cross section is governed by a. (above).

choose external (0) or internal (1) rings=1
        1

 13 decision variable candidates have now been identified.
 50 decision variable candidates are permitted.
 37 additional decision variable candidates are allowed.

Is the panel curved in the plane of the screen (Y for cyls.)?=h

We are referring here to the module cross section.  Is the
skin curved as we look at the module cross section? If this
is a cylindrical panel rather than a flat panel your answer
should be Y.

Is the panel curved in the plane of the screen (Y for cyls.)?=y
y
Radius of curvature (cyl. rad.) in the plane of screen, R=100.
  100.0000
Is panel curved normal to plane of screen? (answer N)=n
n

You will next be asked to provide material properties corres-
```

ponding to the material types that you have already indicated.

```
MATERIAL PROPERTIES FOR MATERIAL TYPE  1
Is this material isotropic (Y or N)?=y
y
Young's modulus,                E( 1)=10.E+06
 0.1000000E+08
Poisson's ratio,               NU( 1)=.3
 0.3000000
transverse shear modulus,      G13( 1)=3.846154E+06
  3846154.
Thermal expansion coeff.,    ALPHA( 1)=0
        0
residual stress temperature (positive),TEMPTUR( 1)=0
        0
Want to supply a stress-strain "curve" for this mat'l (H)?=n
n
Want to specify  maximum effective stress ?=h

For isotropic material the answer is usually Y  .
For orthotropic material the answer must be  N . In the ortho-
tropic case you must specify maximum tensile and compressive
and shear stresses in the principle material directions
(along the fibers and normal to them).

Want to specify  maximum effective stress ?=y
y
Maximum allowable effective stress in material type( 1)=60000.
  60000.00

  2 allowables have now been identified.
 50 allowables are permitted.
 48 additional allowables are permitted.
```

Sometimes optimum designs are obtained for composite laminates with models in which the ENTIRE LAMINATE is treated as one layer, rather than on a ply-by-ply basis. Input data for stress allowables are generally obtained from membrane and bending tests on the ENTIRE LAMINATE. Laminate tests usually reveal that the maximum bending stress before failure of the laminate is significantly larger than the maximum membrane stress. In order to exploit this "bending overshoot" during optimization, it is necessary to include stress constraints of the form:

max.stress constraint = 1/[S(membrane)/S(a) +S(bending)/(f*S(a))]

in which "S" means "stress" and "a" means "allowable". The quantity "f" is a "bending overshoot factor", which might be different for as many as five different conditions:

1. S(membrane) is axial tensile; 2. S(membrane) is axial compressive
3. S(membrane) is "hoop"tensile: 4. S(membrane) is "hoop"compressive
5. S(membrane) is in-plane shear stress.

Accordingly, you will next be prompted whether or not you want to take advantage of "bending overshoot". If you answer "Y" and the current material does NOT have a single maximum allowable effective stress, you will then be prompted for the following five bending overshoot factors, fxt, fxc, fyt, fyc, fxy (each greater than unity):
      1. f(axial tensile) =fxt;   2. f(axial compressive) =fxc

```
      3. f("hoop" tensile)=fyt;   4. f("hoop" compressive)=fyc
      5. f(in-plane shear)=fxy
"hoop" means normal to the axial direction in the plane of the
panel module segment (the "s"- or "y"-coordinate in Fig. 9 of the
long 1987 PANDA2 paper in Computers and Structures, pp 469-605).
If you have previously indicated that the material has a single
maximum "effective" stress (in the von Mises sense), then you
will simply be prompted for one quantity, f, which is the single
"bending overshoot" factor (greater than unity). NOTE: IF YOU
ELECT TO TAKE ADVANTAGE OF THE "BENDING OVERSHOOT", YOU MUST TREAT
THIS MATERIAL AS A DIFFERENT MATERIAL IF THE SAME MATERIAL APPEARS
ELSEWHERE IN A MULTILAYER SEGMENT.

Do you want to take advantage of "bending overshoot"?=n
n
weight density (greater than 0!) of material type( 1)=0.1
 0.1000000
Is lamina cracking permitted along fibers (type H(elp))?=h

If this material is isotropic or cloth or has fibers running in
both directions, answer N.

If you answer Y, two things will happen in PANDA2:

1. Cracking due to tension normal to the fiber direction
   will not be treated as failure. Instead, if PANDA2 perceives
   that the allowable stress for tension normal to the fibers
   in a lamina is exceeded, the allowable for compression along
   the fibers in that material at that particular location in
   the laminate will be reduced by half and the allowable for
   in-plane shear will be reduced by 20 per cent.

2. If during design changes the thickness of any layer made
   of this material becomes less than a quarter of that which
   you give as the minimum thickness (such as .005 in.) the
   layer will disappear.

 If you answer N, even though the material is unidirectional,
 cracking due to tension normal to the fibers will be treated
 as failure, and the layer will never disappear no matter how
 thin it gets during optimization iterations.

Is lamina cracking permitted along fibers (type H(elp))?=n
n

 26 fixed parameters have now been identified.
 99 fixed parameters are permitted.
 73 additional fixed parameters are allowed.


SOME ADVICE ON MODELING WHEN NORMAL PRESSURE IS PRESENT:
If you are designing a panel that has both stringers and rather
large rings, and you expect that in the prebuckling phase there
may be significant bending between these large rings due to the
pressure, then set up models in which there are stringers only.
The entire axial length of each model must be equal to the
spacing of the large rings. The boundary conditions along the
edges where the large rings are supposed to be should be clamped
for the prebuckling phase and simply supported for the buckling
phase of the analysis if the stringers are not tapered in the
neighborhoods of the large rings.  If the stringers are tapered
near the large rings, then use simple support for both the
prebuckling and the buckling phases of the analysis.
```

```
Prebuckling: choose 0=bending included; 2=use membrane theory=h

This prompt is used for boundary conditions for curved (cylindrical)
panels only. Please reply either 0 or 2 .

What is meant here is the b.c. for the two CURVED boundaries only.
The straight boundaries, that is, the two edges that are normal to
the plane of the screen, are always assumed to be symmetry conditions
for the prebuckling phase of the analysis (but uniform in-plane
shearing is permitted).

0 = Prebuckling axisymmetric axial bending is included. Please see
    pp 495-498 in the paper, "Approximate method for the...",
    Computers & Structures, Vol.59, pp 489-527, 1996 for an
    explanation of the axisymmetric prebuckling theory used in PANDA2.

2 = The prebuckled state is derived from membrane theory. That is,
    both the stringers and rings are smeared out and the presence
    of constraint along the two curved edges and where rings occur
    is ignored. The prebuckled membrane deformation is uniform.

Cases in which membrane prebuckling theory is used will run quicker
because there is only one Subcase per load set. However, the fact is
that conditions are actually different midway between rings from
those that exist at the rings because of prebuckling axisymmetric
bending. You may want to optimize first with use of membrane theory,
then permit bending for further optimization.

If the panel is curved and there are no rings, use membrane theory.

Prebuckling: choose 0=bending included; 2=use membrane theory=2
        2
Buckling: choose 0=simple support or 1=clamping=h

What is meant here is the boundary conditions for the two
edges that lie in the plane of the screen and parallel to this
plane  (the two curved edges if the panel is cylindrical).

Use simple support if the ends of the panel represent the
locations of rings, as discussed above. Use simple support
if the stringers are tapered at the ends of the panel.

NOTE: If you are using PANDA2 to analyze a ring-stiffened
      cylindrical shell, use simple support (0) here. If you
      have chosen the arc length of the panel in the plane of
      the screen to be equal to pi*radius of the cylinder,
      then the number of half waves over this arc length will
      be equal to the number of full waves in the buckling
      pattern around the entire circumference of a complete
      (360 deg.) cylindrical shell. Thus, the PANDA2 analysis
      of a panel spanning 180 deg. is equivalent to an
      analysis of a complete (360 deg.) cylindrical shell.

Buckling: choose 0=simple support or 1=clamping=0
        0

 28 fixed parameters have now been identified.
 99 fixed parameters are permitted.
 71 additional fixed parameters are allowed.


DESCRIPTION OF FILES GENERATED BY THIS CASE:
```

```
 cylstif.NAM = This file contains only the name of the case.
 cylstif.BEG = Summary of interactive session you have just
          completed. This file can be edited and used for
          future runs of BEGIN.

 cylstif.CBL = Contains part of cylstif data base.

 cylstif.OPB = Output from BEGIN. Please list this file and
          inspect it and the cylstif.BEG file carefully before
          proceeding.

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

 Next, give a command  CHANGE or CHOOSETEMP  or   SETUP   .

----------- end of the interactive "BEGIN" session ---------------


The files that now exist in the working directory are as follows:

-rw-r--r--   1 bush bush   5604 Feb 21 11:18 cylstif.BEG
-rw-r--r--   1 bush bush 182500 Feb 21 11:18 cylstif.CBL
-rw-r--r--   1 bush bush     30 Feb 21 11:18 cylstif.NAM
-rw-r--r--   1 bush bush  12112 Feb 21 11:18 cylstif.OPB

The user-provided input data supplied during the interactive
"BEGIN" session are saved in the file, cylstif.BEG. A list of
cylstif.BEG follows:
-------------------------------------------------------------
      n          $ Do you want a tutorial session and tutorial output?
       300       $ Panel length normal to the plane of the screen, L1
   314.1600      $ Panel length in the plane of the screen, L2
      t          $ Identify type of stiffener along L1 (N,T,J,Z,R,A,C,G)
        30       $ stiffener spacing, b
   10.00000      $ width of stringer base, b2 (must be > 0, see Help)
   10.00000      $ height of stiffener (type H for sketch), h
   10.00000      $ width of outstanding flange of stiffener, w
      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)
         1       $ material index (1,2,...) for layer index no.( 2)
      n          $ Any more layers or groups of layers in Segment no.( 3)
```

```
      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.( 4)
      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)
         1      $ material index (1,2,...) for layer index no.( 3)
      n         $ Any more layers or groups of layers in Segment no.( 4)
         0      $ choose external (0) or internal (1) stringers
      t         $ Identify type of stiffener along L2  (N, T, J, Z, R, A)
   50.00000     $ stiffener spacing, b
         0      $ width of ring base, b2 (zero is allowed)
   10.00000     $ height of stiffener (type H for sketch), h
   10.00000     $ width of outstanding flange of stiffener, w
      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?
         4      $ layer index (1,2,...), for layer no.( 1)
      y         $ Is this a new layer type?
  0.1000000     $ thickness for layer index no.( 4)
         0      $ winding angle (deg.) for layer index no.( 4)
         1      $ material index (1,2,...) for layer index no.( 4)
      n         $ Any more layers or groups of layers in Segment no.( 3)
      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.( 4)
      n         $ Can winding (layup) angles ever be decision variables?
         5      $ layer index (1,2,...), for layer no.( 1)
      y         $ Is this a new layer type?
  0.1000000     $ thickness for layer index no.( 5)
         0      $ winding angle (deg.) for layer index no.( 5)
         1      $ material index (1,2,...) for layer index no.( 5)
      n         $ Any more layers or groups of layers in Segment no.( 4)
         1      $ choose external (0) or internal (1) rings
      y         $ Is the panel curved in the plane of the screen (Y for cyls.)?
   100.0000     $ Radius of curvature (cyl. rad.) in the plane of screen, R
      n         $ Is panel curved normal to plane of screen? (answer N)
      y         $ Is this material isotropic (Y or N)?
  0.1000000E+08 $ Young's modulus,                E( 1)
  0.3000000     $ Poisson's ratio,               NU( 1)
   3846154.     $ 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 (H)?
      y         $ Want to specify  maximum effective stress ?
   60000.00     $ Maximum allowable effective stress in material type( 1)
      n         $ Do you want to take advantage of "bending overshoot"?
  0.1000000     $ weight density (greater than 0!) of material type( 1)
      n         $ Is lamina cracking permitted along fibers (type H(elp))?
         2      $ Prebuckling: choose 0=bending included; 2=use membrane theory
         0      $ Buckling: choose 0=simple support or 1=clamping
---------------- end of the cylstif.BEG file (input for "BEGIN") ---------------
```

This cylstif.BEG file can be edited and used for future executions of BEGIN
for the same or very similar cases.

PART 1.3: Execute the PANDA2 processor called "SETUP". SETUP sets up templates for BOSOR4-type of models.

bush-> setup

```
Enter case name: cylstif

Running PANDA2: setup, case: cylstif

----------------------------
Executing setup


  **************   SETUP   ***************

  The purpose of SETUP is to set up an input data file called
  NAME.ALL, in which NAME is your name for this case.  This
  file, NAME.ALL, is a BOSOR4-type of input data file. It is
  used as input for B4READ.

  **********************************************


     GENERATING BOSOR4-TYPE DISCRETIZED MODELS
            FOR A SINGLE PANEL MODULE
 AND FOR THE ENTIRE PANEL WIDTH WITH SMEARED STRINGERS

 The command SETUP causes templates
 of the stiffness and  load-geometric matrices to
 be set up for the buckling problems involving:

   1. a single panel module, which is
      used for:

        a. local buckling and postbuckling
           analysis,
        b. wide column buckling analysis, and
        c. the nonlinear local static response of
           an  axially stiffened panel to uniform
           normal pressure.

   2. the entire panel with smeared stiffeners,
      which is used for:

        a. general instability for a panel with
           an axial load that varies across the
           span of the panel, and

        b. the nonlinear overall static response
           of a stiffened panel to uniform
           normal pressure.

 Much of the BOSOR4 preprocessor software is used
 to do this.  Therefore, in order to use PANDA2
 you must have available to you the most recent
 version of BOSOR4.



 DESCRIPTION OF FILES GENERATED BY THIS CASE:

 cylstif.ALL = Input data for BOSOR4-type of preprocessor.
           correponding to discretized single panel module.
 cylstif.BOS = Input data for BOSOR4-type of preprocessor.
           correponding to discretized entire panel with
           smeared stiffeners.
 cylstif.CBL = Contains part of cylstif data base.
```

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

 The next module will cause to be generated matrix templates
 for solution of the local and general buckling eigenvalue
 problems in which the cross section of the panel module is
 discretized and in which the entire panel cross section is
 discretized (smeared stiffeners) according to the conventions
 used in BOSOR4.

----------------------------
Normal termination: setup
still processing... Please wait.
----------------------------
Executing setup2


  **************   SETUP2  ***************

  The purpose of SETUP2 is to set up an input data file called
  NAME.AL2, in which NAME is your name for this case.  This
  file, NAME.AL2, is a BOSOR4-type of input data file. It is
  used as input for B4READ. SETUP2 is for skin-ring module.

  ***********************************************


     GENERATING BOSOR4-TYPE DISCRETIZED MODEL
     FOR A SINGLE PANEL SKIN-RING MODULE

 The command  SETUP2 causes templates
 of the stiffness and  load-geometric matrices to
 be set up for the buckling problems involving:

   1. a single panel skin-ring module, which is
      used for:

        a. local buckling analysis and
        b. the nonlinear local static response of
           a ring stiffened panel to uniform
           normal pressure and axial compression.



 DESCRIPTION OF FILES GENERATED BY THIS CASE:

 cylstif.AL2 = Input data for BOSOR4-type of preprocessor.
 correponding to discretized single skin-ring panel module.
 cylstif.CBL = Contains part of cylstif data base.

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

 This command will cause to be generated matrix templates
 for solution of the local skin-ring buckling eigenvalue
 problem in which the panel module cross section is discretized
 according to the conventions used in BOSOR4.

 Next give either the command DECIDE or MAINSETUP.

----------------------------
Normal termination: setup2
still processing... Please wait.
```

```
----------------------------
Executing setup3


  **************   SETUP3  ***************

 The purpose of SETUP3 is to set up an input data file called
 NAME.AL3, in which NAME is your name for this case.  This
  file, NAME.AL3, is a BOSOR4-type of input data file. It is
  used as input for B4READ. (skin-substringer module-2004).

  **********************************************


     GENERATING BOSOR4-TYPE DISCRETIZED MODEL
     FOR A SINGLE PANEL MODULE (skin+substringer)
 The command SETUP3 causes templates
 of the stiffness and  load-geometric matrices to
 be set up for the buckling problem involving
 a single panel module with skin and substringer,
 which is used for local buckling analysis.



 DESCRIPTION OF FILES GENERATED BY THIS CASE:

 cylstif.AL3 = Input data for BOSOR4-type of preprocessor.
           correponding to discretized single panel module
           consisting of skin and substringer.
 cylstif.CBL = Contains part of cylstif data base.

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

 The next module will cause to be generated matrix templates
 for solution of the local buckling eigenvalue problem
 in which the cross section of the panel module is
 discretized (skin+substringer) according to the conventions
 used in BOSOR4.

----------------------------
Normal termination: setup3
still processing... Please wait.
----------------------------
Executing pandaread - 1st pass
Normal termination: pandaread 1
Skin-stringer panel module templates finished.
still processing... Please wait.
----------------------------
Executing pandaread - 2nd pass
Normal termination: pandaread 2
Entire smeared panel templates finished.
still processing... Please wait.
----------------------------
Executing globst
Normal termination: globst
Global model common blocks stored.
----------------------------
----------------------------
Executing pandaread - 3rd pass
Normal termination: pandaread 3
skin-ring panel module templates finished.
still processing... Please wait.
----------------------------
```

```
Executing glbst2
Normal termination: glbst2
skin-ring panel module common blocks stored.
----------------------------
----------------------------
Executing pandaread - 4th pass
Normal termination: pandaread 4
skin-substringer panel module templates finished.
still processing... Please wait.
----------------------------
Executing glbst3
Normal termination: glbst3
skin-substringer panel module common blocks stored.
Pandaread pre-processor complete.
Next give the command: DECIDE or MAINSETUP.
```

The files existing in the working directory after the execution of "SETUP" are as follows:

```
-rw-r--r--   1 bush bush     76 Feb 21 12:44 cylstif.010
-rw-r--r--   1 bush bush   2046 Feb 21 11:27 cylstif.AL2
-rw-r--r--   1 bush bush   2058 Feb 21 11:27 cylstif.AL3
-rw-r--r--   1 bush bush   2058 Feb 21 11:27 cylstif.ALL
-rw-r--r--   1 bush bush   5604 Feb 21 11:18 cylstif.BEG
-rw-r--r--   1 bush bush 110324 Feb 21 11:27 cylstif.BL1
-rw-r--r--   1 bush bush 110324 Feb 21 11:27 cylstif.BL2
-rw-r--r--   1 bush bush 110324 Feb 21 11:27 cylstif.BL3
-rw-r--r--   1 bush bush 110324 Feb 21 11:27 cylstif.BL4
-rw-r--r--   1 bush bush    481 Feb 21 11:27 cylstif.BOS
-rw-r--r--   1 bush bush 182500 Feb 21 11:48 cylstif.CBL
-rw-r--r--   1 bush bush     30 Feb 21 11:18 cylstif.NAM
-rw-r--r--   1 bush bush  12112 Feb 21 11:18 cylstif.OPB
-rw-r--r--   1 bush bush  33792 Feb 21 11:27 cylstif.RN1
-rw-r--r--   1 bush bush  36864 Feb 21 11:27 cylstif.RN2
-rw-r--r--   1 bush bush  33792 Feb 21 11:27 cylstif.RN3
-rw-r--r--   1 bush bush  33792 Feb 21 11:27 cylstif.RN4
```

PART 1.4: Execute the PANDA2 processor called "DECIDE" in order to choose decision variables, upper and lower bounds, equality constraints, inequality constraints, and "escape" variables

bush-> decide

```
Please enter PANDA2 case name: cylstif


 *****************   DECIDE   ******************

 The purpose of DECIDE is to permit you to choose decision
 variables, linked variables, and escape variables for the
 optimization run or runs to follow. The results of the
 interactive session are saved in a file called cylstif.DEC, in
 which cylstif is your name for the case. You may find this file
 useful for future runs of DECIDE in which you want to avoid
 answering many questions interactively. DECIDE also generates
 a file called cylstif.OPD.  cylstif.OPD contains a summary of
 optimization parameters. If you choose the tutorial option,
 cylstif.OPD contains a complete list of the interactive session,
 including prompting questions, all "help" paragraphs, your
 responses to the prompting questions, and evolving lists
```

```
of optimization parameters as they are chosen by you.

****************************************************

Are you correcting, adding to, or using an existing file?=n
n
Do you want a tutorial session and tutorial output?=n
n
PARAMETERS FROM WHICH A DECISION VARIABLE MUST NOW BE CHOSEN
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE            DEFINITION
 1         0     0   3.000E+01       B(STR):stiffener spacing, b: STR seg=NA,
 2   STR   2     0   1.000E+01      B2(STR):width of stringer base, b2 (must
 3   STR   3     0   1.000E+01       H(STR):height of stiffener (type H for s
 4   STR   4     0   1.000E+01       W(STR):width of outstanding flange of st
 5   SKN   1     1   1.000E-01   T(1 )(SKN):thickness for layer index no.(1 )
 6   STR   3     1   1.000E-01   T(2 )(STR):thickness for layer index no.(2 )
 7   STR   4     1   1.000E-01   T(3 )(STR):thickness for layer index no.(3 )
 8         0     0   5.000E+01       B(RNG):stiffener spacing, b: RNG seg=NA,
10   RNG   3     0   1.000E+01       H(RNG):height of stiffener (type H for s
11   RNG   4     0   1.000E+01       W(RNG):width of outstanding flange of st
12   RNG   3     1   1.000E-01   T(4 )(RNG):thickness for layer index no.(4 )
13   RNG   4     1   1.000E-01   T(5 )(RNG):thickness for layer index no.(5 )
Want to use default for thickness decision variables (type H(elp)?=h

It is sometimes best to answer Y if you have a lot of different
layer types. However, it is a bit tricky and YOU MUST BE CAREFUL.
You answer Y or N.  Your answer means:
 N   means you choose thickness decision variables one-by-one.
 Y   means that for a certain range of layer index types, to be
     specified by you, the following will happen:
    1. the thickness of any layer type for which the winding
       angle is either 0 or 90 deg. will be a decision variable.
    2. the thickness of any layer type will be a decision
       variable, regardless of winding angle, if the winding
       angle of any previous layer type within the given range
       of layer types is not equal to minus the winding angle
       of the current layer type.
    3. If the current winding angle is minus some previous
       winding angle within the given range of layer types,
       the current thickness will be linked to that previous
       thickness, and the linking constant C will be 1.0.
NOTE: You must choose lowest and highest layer indeces from a
      GIVEN SEGMENT in the module cross section, NOT from the
      entire module, and a skin-stringer module must be done
      separately from a skin-ring module. You MUST answer N
      if winding angles are decision variables.

Want to use default for thickness decision variables (type H(elp)?=n
n
Choose a decision variable (1,2,3,...)=h

Use an index from the left-hand column of the table above.

Choose a decision variable (1,2,3,...)=1
        1
Lower bound of variable no.( 1)=10
       10
Upper bound of variable no.( 1)=50
       50
Any more decision variables (Y or N) ?=y
y
           DECISION VARIABLES CHOSEN SO FAR
VAR. STR/ SEG. LAYER   CURRENT
```

```
NO.  RNG  NO.   NO.     VALUE            DEFINITION
 1         0     0   3.000E+01       B(STR):stiffener spacing, b: STR seg=NA,
PARAMETERS FROM WHICH A DECISION VARIABLE MUST NOW BE CHOSEN
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE            DEFINITION
 2   STR   2     0   1.000E+01      B2(STR):width of stringer base, b2 (must
 3   STR   3     0   1.000E+01       H(STR):height of stiffener (type H for s
 4   STR   4     0   1.000E+01       W(STR):width of outstanding flange of st
 5   SKN   1     1   1.000E-01   T(1 )(SKN):thickness for layer index no.(1 )
 6   STR   3     1   1.000E-01   T(2 )(STR):thickness for layer index no.(2 )
 7   STR   4     1   1.000E-01   T(3 )(STR):thickness for layer index no.(3 )
 8         0     0   5.000E+01       B(RNG):stiffener spacing, b: RNG seg=NA,
10   RNG   3     0   1.000E+01       H(RNG):height of stiffener (type H for s
11   RNG   4     0   1.000E+01       W(RNG):width of outstanding flange of st
12   RNG   3     1   1.000E-01   T(4 )(RNG):thickness for layer index no.(4 )
13   RNG   4     1   1.000E-01   T(5 )(RNG):thickness for layer index no.(5 )
Choose a decision variable (1,2,3,...)=3
        3
Lower bound of variable no.( 3)=0.5
 0.5000000
Upper bound of variable no.( 3)=20.
  20.00000
Any more decision variables (Y or N) ?=y
y
           DECISION VARIABLES CHOSEN SO FAR
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE            DEFINITION
 1         0     0   3.000E+01       B(STR):stiffener spacing, b: STR seg=NA,
 3   STR   3     0   1.000E+01       H(STR):height of stiffener (type H for s
PARAMETERS FROM WHICH A DECISION VARIABLE MUST NOW BE CHOSEN
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE            DEFINITION
 2   STR   2     0   1.000E+01      B2(STR):width of stringer base, b2 (must
 4   STR   4     0   1.000E+01       W(STR):width of outstanding flange of st
 5   SKN   1     1   1.000E-01   T(1 )(SKN):thickness for layer index no.(1 )
 6   STR   3     1   1.000E-01   T(2 )(STR):thickness for layer index no.(2 )
 7   STR   4     1   1.000E-01   T(3 )(STR):thickness for layer index no.(3 )
 8         0     0   5.000E+01       B(RNG):stiffener spacing, b: RNG seg=NA,
10   RNG   3     0   1.000E+01       H(RNG):height of stiffener (type H for s
11   RNG   4     0   1.000E+01       W(RNG):width of outstanding flange of st
12   RNG   3     1   1.000E-01   T(4 )(RNG):thickness for layer index no.(4 )
13   RNG   4     1   1.000E-01   T(5 )(RNG):thickness for layer index no.(5 )
Choose a decision variable (1,2,3,...)=4
        4
Lower bound of variable no.( 4)=0.5
 0.5000000
Upper bound of variable no.( 4)=10.
  10.00000
Any more decision variables (Y or N) ?=y
y
           DECISION VARIABLES CHOSEN SO FAR
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE            DEFINITION
 1         0     0   3.000E+01       B(STR):stiffener spacing, b: STR seg=NA,
 3   STR   3     0   1.000E+01       H(STR):height of stiffener (type H for s
 4   STR   4     0   1.000E+01       W(STR):width of outstanding flange of st
PARAMETERS FROM WHICH A DECISION VARIABLE MUST NOW BE CHOSEN
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE            DEFINITION
 2   STR   2     0   1.000E+01      B2(STR):width of stringer base, b2 (must
 5   SKN   1     1   1.000E-01   T(1 )(SKN):thickness for layer index no.(1 )
 6   STR   3     1   1.000E-01   T(2 )(STR):thickness for layer index no.(2 )
 7   STR   4     1   1.000E-01   T(3 )(STR):thickness for layer index no.(3 )
 8         0     0   5.000E+01       B(RNG):stiffener spacing, b: RNG seg=NA,
```

```
10   RNG   3     0   1.000E+01        H(RNG):height of stiffener (type H for s
11   RNG   4     0   1.000E+01        W(RNG):width of outstanding flange of st
12   RNG   3     1   1.000E-01    T(4 )(RNG):thickness for layer index no.(4 )
13   RNG   4     1   1.000E-01    T(5 )(RNG):thickness for layer index no.(5 )
Choose a decision variable (1,2,3,...)=5
        5
Lower bound of variable no.( 5)=.05
 0.5000000E-01
Upper bound of variable no.( 5)=1.0
  1.000000
Any more decision variables (Y or N) ?=y
y
           DECISION VARIABLES CHOSEN SO FAR
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE            DEFINITION
 1         0     0   3.000E+01        B(STR):stiffener spacing, b: STR seg=NA,
 3   STR   3     0   1.000E+01        H(STR):height of stiffener (type H for s
 4   STR   4     0   1.000E+01        W(STR):width of outstanding flange of st
 5   SKN   1     1   1.000E-01    T(1 )(SKN):thickness for layer index no.(1 )
PARAMETERS FROM WHICH A DECISION VARIABLE MUST NOW BE CHOSEN
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE            DEFINITION
 2   STR   2     0   1.000E+01       B2(STR):width of stringer base, b2 (must
 6   STR   3     1   1.000E-01    T(2 )(STR):thickness for layer index no.(2 )
 7   STR   4     1   1.000E-01    T(3 )(STR):thickness for layer index no.(3 )
 8         0     0   5.000E+01        B(RNG):stiffener spacing, b: RNG seg=NA,
10   RNG   3     0   1.000E+01        H(RNG):height of stiffener (type H for s
11   RNG   4     0   1.000E+01        W(RNG):width of outstanding flange of st
12   RNG   3     1   1.000E-01    T(4 )(RNG):thickness for layer index no.(4 )
13   RNG   4     1   1.000E-01    T(5 )(RNG):thickness for layer index no.(5 )
Choose a decision variable (1,2,3,...)=6
        6
Lower bound of variable no.( 6)=.01
 0.1000000E-01
Upper bound of variable no.( 6)=1.
  1.000000
Any more decision variables (Y or N) ?=y
y
           DECISION VARIABLES CHOSEN SO FAR
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE            DEFINITION
 1         0     0   3.000E+01        B(STR):stiffener spacing, b: STR seg=NA,
 3   STR   3     0   1.000E+01        H(STR):height of stiffener (type H for s
 4   STR   4     0   1.000E+01        W(STR):width of outstanding flange of st
 5   SKN   1     1   1.000E-01    T(1 )(SKN):thickness for layer index no.(1 )
 6   STR   3     1   1.000E-01    T(2 )(STR):thickness for layer index no.(2 )
PARAMETERS FROM WHICH A DECISION VARIABLE MUST NOW BE CHOSEN
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE            DEFINITION
 2   STR   2     0   1.000E+01       B2(STR):width of stringer base, b2 (must
 7   STR   4     1   1.000E-01    T(3 )(STR):thickness for layer index no.(3 )
 8         0     0   5.000E+01        B(RNG):stiffener spacing, b: RNG seg=NA,
10   RNG   3     0   1.000E+01        H(RNG):height of stiffener (type H for s
11   RNG   4     0   1.000E+01        W(RNG):width of outstanding flange of st
12   RNG   3     1   1.000E-01    T(4 )(RNG):thickness for layer index no.(4 )
13   RNG   4     1   1.000E-01    T(5 )(RNG):thickness for layer index no.(5 )
Choose a decision variable (1,2,3,...)=7
        7
Lower bound of variable no.( 7)=.01
 0.1000000E-01
Upper bound of variable no.( 7)=1.
  1.000000
Any more decision variables (Y or N) ?=y
y
```

```
           DECISION VARIABLES CHOSEN SO FAR
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE            DEFINITION
 1         0     0   3.000E+01        B(STR):stiffener spacing, b: STR seg=NA,
 3   STR   3     0   1.000E+01        H(STR):height of stiffener (type H for s
 4   STR   4     0   1.000E+01        W(STR):width of outstanding flange of st
 5   SKN   1     1   1.000E-01    T(1 )(SKN):thickness for layer index no.(1 )
 6   STR   3     1   1.000E-01    T(2 )(STR):thickness for layer index no.(2 )
 7   STR   4     1   1.000E-01    T(3 )(STR):thickness for layer index no.(3 )
PARAMETERS FROM WHICH A DECISION VARIABLE MUST NOW BE CHOSEN
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE            DEFINITION
 2   STR   2     0   1.000E+01       B2(STR):width of stringer base, b2 (must
 8         0     0   5.000E+01        B(RNG):stiffener spacing, b: RNG seg=NA,
10   RNG   3     0   1.000E+01        H(RNG):height of stiffener (type H for s
11   RNG   4     0   1.000E+01        W(RNG):width of outstanding flange of st
12   RNG   3     1   1.000E-01    T(4 )(RNG):thickness for layer index no.(4 )
13   RNG   4     1   1.000E-01    T(5 )(RNG):thickness for layer index no.(5 )
Choose a decision variable (1,2,3,...)=8
        8
Lower bound of variable no.( 8)=10.
  10.00000
Upper bound of variable no.( 8)=100.
  100.0000
Any more decision variables (Y or N) ?=y
y
           DECISION VARIABLES CHOSEN SO FAR
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE            DEFINITION
 1         0     0   3.000E+01        B(STR):stiffener spacing, b: STR seg=NA,
 3   STR   3     0   1.000E+01        H(STR):height of stiffener (type H for s
 4   STR   4     0   1.000E+01        W(STR):width of outstanding flange of st
 5   SKN   1     1   1.000E-01    T(1 )(SKN):thickness for layer index no.(1 )
 6   STR   3     1   1.000E-01    T(2 )(STR):thickness for layer index no.(2 )
 7   STR   4     1   1.000E-01    T(3 )(STR):thickness for layer index no.(3 )
 8         0     0   5.000E+01        B(RNG):stiffener spacing, b: RNG seg=NA,
PARAMETERS FROM WHICH A DECISION VARIABLE MUST NOW BE CHOSEN
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE            DEFINITION
 2   STR   2     0   1.000E+01       B2(STR):width of stringer base, b2 (must
10   RNG   3     0   1.000E+01        H(RNG):height of stiffener (type H for s
11   RNG   4     0   1.000E+01        W(RNG):width of outstanding flange of st
12   RNG   3     1   1.000E-01    T(4 )(RNG):thickness for layer index no.(4 )
13   RNG   4     1   1.000E-01    T(5 )(RNG):thickness for layer index no.(5 )
Choose a decision variable (1,2,3,...)=10
       10
Lower bound of variable no.(10)=.5
 0.5000000
Upper bound of variable no.(10)=20.
  20.00000
Any more decision variables (Y or N) ?=y
y
           DECISION VARIABLES CHOSEN SO FAR
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE            DEFINITION
 1         0     0   3.000E+01        B(STR):stiffener spacing, b: STR seg=NA,
 3   STR   3     0   1.000E+01        H(STR):height of stiffener (type H for s
 4   STR   4     0   1.000E+01        W(STR):width of outstanding flange of st
 5   SKN   1     1   1.000E-01    T(1 )(SKN):thickness for layer index no.(1 )
 6   STR   3     1   1.000E-01    T(2 )(STR):thickness for layer index no.(2 )
 7   STR   4     1   1.000E-01    T(3 )(STR):thickness for layer index no.(3 )
 8         0     0   5.000E+01        B(RNG):stiffener spacing, b: RNG seg=NA,
10   RNG   3     0   1.000E+01        H(RNG):height of stiffener (type H for s
PARAMETERS FROM WHICH A DECISION VARIABLE MUST NOW BE CHOSEN
```

```
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE             DEFINITION
 2   STR   2     0   1.000E+01       B2(STR):width of stringer base, b2 (must
11   RNG   4     0   1.000E+01        W(RNG):width of outstanding flange of st
12   RNG   3     1   1.000E-01    T(4 )(RNG):thickness for layer index no.(4 )
13   RNG   4     1   1.000E-01    T(5 )(RNG):thickness for layer index no.(5 )
Choose a decision variable (1,2,3,...)=11
       11
Lower bound of variable no.(11)=0.5
 0.5000000
Upper bound of variable no.(11)=10.
  10.00000
Any more decision variables (Y or N) ?=y
y
           DECISION VARIABLES CHOSEN SO FAR
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE             DEFINITION
 1         0     0   3.000E+01        B(STR):stiffener spacing, b: STR seg=NA,
 3   STR   3     0   1.000E+01        H(STR):height of stiffener (type H for s
 4   STR   4     0   1.000E+01        W(STR):width of outstanding flange of st
 5   SKN   1     1   1.000E-01    T(1 )(SKN):thickness for layer index no.(1 )
 6   STR   3     1   1.000E-01    T(2 )(STR):thickness for layer index no.(2 )
 7   STR   4     1   1.000E-01    T(3 )(STR):thickness for layer index no.(3 )
 8         0     0   5.000E+01        B(RNG):stiffener spacing, b: RNG seg=NA,
10   RNG   3     0   1.000E+01        H(RNG):height of stiffener (type H for s
11   RNG   4     0   1.000E+01        W(RNG):width of outstanding flange of st
PARAMETERS FROM WHICH A DECISION VARIABLE MUST NOW BE CHOSEN
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE             DEFINITION
 2   STR   2     0   1.000E+01       B2(STR):width of stringer base, b2 (must
12   RNG   3     1   1.000E-01    T(4 )(RNG):thickness for layer index no.(4 )
13   RNG   4     1   1.000E-01    T(5 )(RNG):thickness for layer index no.(5 )
Choose a decision variable (1,2,3,...)=12
       12
Lower bound of variable no.(12)=.01
 0.1000000E-01
Upper bound of variable no.(12)=1.
  1.000000
Any more decision variables (Y or N) ?=y
y
           DECISION VARIABLES CHOSEN SO FAR
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE             DEFINITION
 1         0     0   3.000E+01        B(STR):stiffener spacing, b: STR seg=NA,
 3   STR   3     0   1.000E+01        H(STR):height of stiffener (type H for s
 4   STR   4     0   1.000E+01        W(STR):width of outstanding flange of st
 5   SKN   1     1   1.000E-01    T(1 )(SKN):thickness for layer index no.(1 )
 6   STR   3     1   1.000E-01    T(2 )(STR):thickness for layer index no.(2 )
 7   STR   4     1   1.000E-01    T(3 )(STR):thickness for layer index no.(3 )
 8         0     0   5.000E+01        B(RNG):stiffener spacing, b: RNG seg=NA,
10   RNG   3     0   1.000E+01        H(RNG):height of stiffener (type H for s
11   RNG   4     0   1.000E+01        W(RNG):width of outstanding flange of st
12   RNG   3     1   1.000E-01    T(4 )(RNG):thickness for layer index no.(4 )
PARAMETERS FROM WHICH A DECISION VARIABLE MUST NOW BE CHOSEN
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE             DEFINITION
 2   STR   2     0   1.000E+01       B2(STR):width of stringer base, b2 (must
13   RNG   4     1   1.000E-01    T(5 )(RNG):thickness for layer index no.(5 )
Choose a decision variable (1,2,3,...)=13
       13
Lower bound of variable no.(13)=.01
 0.1000000E-01
Upper bound of variable no.(13)=1.
  1.000000
```

```
Any more decision variables (Y or N) ?=n
n

 11 decision variables have now been identified.
 40 decision variables are permitted.
 29 additional decision variables are allowed.


Next, choose linked variables.

A linked variable is a variable that is not a decision
variable, but is expressed in terms of decision variables,
thus:

 (linked variable)  =  C1*(decision variable no. j1)
                      +C2*(decision variable no. j2)
                      +C3*(decision variable no. j3)
                      +etc (up to max. of 5 terms)
                      +C0

 in which C1, C2,..;  and C0 are constants.

For example, material layers with
+ ALPHA degree orientation are usually matched with layers with
- ALPHA degree orientation. Suppose for a certain layer with
winding angle + ALPHA, this winding angle is chosen as a
decision variable.  You want another layer in the same
laminate to have the winding angle - ALPHA.  Then, for this
other layer:

 (winding angle) = -1.0*(winding angle of the layer with +ALPHA)

The winding angle on the left-hand-side of the above
equation is called a linked variable because its value
is linked to that of the first mentioned layer. The linking
constant C1 = -1.0 in this example.

Any linked variables (Y or N) ?=y
y
PARAMETERS FROM WHICH A LINKED VARIABLE MUST NOW BE CHOSEN
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE            DEFINITION
 2   STR   2     0   1.000E+01       B2(STR):width of stringer base, b2 (must
Choose a linked variable (1,2,3,...)=2
        2
LINKED VARIABLE MUST BE LINKED TO ONE OF THE  DECISION VARIABLES
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE            DEFINITION
 1         0     0   3.000E+01        B(STR):stiffener spacing, b: STR seg=NA,
 3   STR   3     0   1.000E+01        H(STR):height of stiffener (type H for s
 4   STR   4     0   1.000E+01        W(STR):width of outstanding flange of st
 5   SKN   1     1   1.000E-01    T(1 )(SKN):thickness for layer index no.(1 )
 6   STR   3     1   1.000E-01    T(2 )(STR):thickness for layer index no.(2 )
 7   STR   4     1   1.000E-01    T(3 )(STR):thickness for layer index no.(3 )
 8         0     0   5.000E+01        B(RNG):stiffener spacing, b: RNG seg=NA,
10   RNG   3     0   1.000E+01        H(RNG):height of stiffener (type H for s
11   RNG   4     0   1.000E+01        W(RNG):width of outstanding flange of st
12   RNG   3     1   1.000E-01    T(4 )(RNG):thickness for layer index no.(4 )
13   RNG   4     1   1.000E-01    T(5 )(RNG):thickness for layer index no.(5 )
To which variable is this variable linked?=1
        1
Assign a value to the linking coefficient, C(j)=0.3333
 0.3333000
     B2(STR):width of stringer base, b2 (must be > 0, see Help): STR seg=2 , lay
```

```
  = +0.3333 *V(1 )
Any other decision variables in the linking expression?=n
n
Any constant C0 in the linking expression (Y or N)?=n
n
Any more linked variables (Y or N) ?=n
n

Next, establish inequality relations among variables
of the two forms:

 1.0 < f(v1,v2,v3,...)    or   1.0 > f(v1,v2,v3,...)

in which the expression f(v1,v2,v3,...) has the form:

  f(v1,v2,v3,...) = C0 +C1*v1**D1 +C2*v2**D2 +C3*v3**D3 + ...
                       +etc (up to max. of 10 terms).
                       + up to 10 cross product terms of the form
                         C(i,j)*v(i)*v(j)

The variables, v1, v2, v3,..., can be any of the variables
that are decision variables or potential candidates for
decision variables or linked variables.

Any inequality relations among variables? (type H)=n
n
Any escape variables (Y or N) ?=h

An escape variable is a variable that when increased
drives the design toward the feasible region. For example, in
designs which are buckling-critical, local and general
instability represent two constraint conditions that bound the
feasible region. Increasing the thicknesses of any parts while
keeping all other dimensions the same drives the design toward
the feasible region (makes buckling less critical). Hence, a
thickness should always be chosen as an escape variable. Other
variables, such as winding angles, should  not be used
as escape variables, since their increase might well result in
a decrease in the buckling load, hence driving the design toward
the infeasible region.

Any escape variables (Y or N) ?=y
y
Want to have escape variables chosen by default?=h

Generally answer Y.  PANDA2 will then automatically choose
as escape variables all of the thicknesses that are decision
variables. This is usually the best strategy and use of the
default option saves you the trouble of doing it interactively.

Want to have escape variables chosen by default?=y
y
          ESCAPE VARIABLES FOR THE OPTIMIZATION PROBLEM
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE            DEFINITION
 5   SKN   1     1   1.000E-01    T(1 )(SKN):thickness for layer index no.(1 )
 6   STR   3     1   1.000E-01    T(2 )(STR):thickness for layer index no.(2 )
 7   STR   4     1   1.000E-01    T(3 )(STR):thickness for layer index no.(3 )
12   RNG   3     1   1.000E-01    T(4 )(RNG):thickness for layer index no.(4 )
13   RNG   4     1   1.000E-01    T(5 )(RNG):thickness for layer index no.(5 )


DESCRIPTION OF FILES GENERATED BY THIS CASE:
```

```
 cylstif.DEC = Summary of interactive session you have just
          completed. This file can be edited and used for
          future runs of DECIDE.

 cylstif.CBL = Contains part of cylstif data base.

 cylstif.OPD = Output from DECIDE. Please list this file and
          inspect it and the cylstif.DEC file carefully before
          proceeding.

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

 Next, give either command  CHOOSETEMP or MAINSETUP   .


The user-provided input data supplied during the "DECIDE"
interactive session are saved in the file, cylstif.DEC. A list
of cylstif.DEC follows:
---------------- cylstif.DEC file (input for DECIDE) -------------
      n         $ Do you want a tutorial session and tutorial output?
      n         $ Want to use default for thickness decision variables (type H(elp)?
         1      $ Choose a decision variable (1,2,3,...)
        10      $ Lower bound of variable no.( 1)
        50      $ Upper bound of variable no.( 1)
      y         $ Any more decision variables (Y or N) ?
         3      $ Choose a decision variable (1,2,3,...)
  0.5000000     $ Lower bound of variable no.( 3)
   20.00000     $ Upper bound of variable no.( 3)
      y         $ Any more decision variables (Y or N) ?
         4      $ Choose a decision variable (1,2,3,...)
  0.5000000     $ Lower bound of variable no.( 4)
   10.00000     $ Upper bound of variable no.( 4)
      y         $ Any more decision variables (Y or N) ?
         5      $ Choose a decision variable (1,2,3,...)
  0.5000000E-01 $ Lower bound of variable no.( 5)
   1.000000     $ Upper bound of variable no.( 5)
      y         $ Any more decision variables (Y or N) ?
         6      $ Choose a decision variable (1,2,3,...)
  0.1000000E-01 $ Lower bound of variable no.( 6)
   1.000000     $ Upper bound of variable no.( 6)
      y         $ Any more decision variables (Y or N) ?
         7      $ Choose a decision variable (1,2,3,...)
  0.1000000E-01 $ Lower bound of variable no.( 7)
   1.000000     $ Upper bound of variable no.( 7)
      y         $ Any more decision variables (Y or N) ?
         8      $ Choose a decision variable (1,2,3,...)
   10.00000     $ Lower bound of variable no.( 8)
   100.0000     $ Upper bound of variable no.( 8)
      y         $ Any more decision variables (Y or N) ?
        10      $ Choose a decision variable (1,2,3,...)
  0.5000000     $ Lower bound of variable no.(10)
   20.00000     $ Upper bound of variable no.(10)
      y         $ Any more decision variables (Y or N) ?
        11      $ Choose a decision variable (1,2,3,...)
  0.5000000     $ Lower bound of variable no.(11)
   10.00000     $ Upper bound of variable no.(11)
      y         $ Any more decision variables (Y or N) ?
        12      $ Choose a decision variable (1,2,3,...)
  0.1000000E-01 $ Lower bound of variable no.(12)
   1.000000     $ Upper bound of variable no.(12)
      y         $ Any more decision variables (Y or N) ?
        13      $ Choose a decision variable (1,2,3,...)
  0.1000000E-01 $ Lower bound of variable no.(13)
```

```
   1.000000     $ Upper bound of variable no.(13)
      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?
--------------- end of the cylstif.DEC file ---------------------
```

```
In future runs of DECIDE you can use the file, cylstif.DEC, as input,
or for very similar cases you can edit the cylstif.DEC file and then
use the edited cylstif.DEC file as input for DECIDE.
------------------------------------------------------------------------
```

PART 1.5: Execute the PANDA2 processor called "MAINSETUP" in order to establish loading and solution strategies.

bush-> mainsetup

```
Please enter PANDA2 case name: cylstif


  *****************   MAINSETUP   ****************
 The purpose of this processor is to permit you to choose loads
 and initial imperfections, Nx, Ny, Nxy, Mx, My, Nxo, Nyo, p,
 T(iseg), Wimp(global), Wimp(local),  (up to 5 sets of them);
 safety factors for general instability, panel instability,
 local instability (panel skin), local instability (stiffener
 parts), and stress; and strategy parameters for subsequent
 batch execution of an optimization analysis (analysis type 1);
 or an analysis of a fixed design at fixed load levels
 (analysis type 2); or an analysis of a fixed design for a
 single load set for monotonically increasing load levels
 (test simulation: analysis type 3).

 Results of the interactive session in MAINSETUP are saved on a
 file called cylstif.OPT, which will appear at the beginning of
 the cylstif.OPM file when the mainprocessor batch run launched
 by your command PANDAOPT has been completed.

 NOTE: JUST HIT "RETURN" FOR DEFAULT VALUE OF INPUT DATUM. IF
   PANDA2 REQUIRES AN INPUT, IT WILL SAY "PLEASE SAY SOMETHING"
  ***************************************************


 Are you correcting, adding to, or using an existing file?=n
 n
 Do you want a tutorial session and tutorial output?=n
 n

 *** NOTE *** NOTE *** NOTE *** NOTE *** NOTE *** NOTE ***
 Your applied loads should correspond to the ULTIMATE load
 condition (in contrast to LIMIT loads or OPERATING loads).
   *** END NOTE *** END NOTE *** END NOTE *** END NOTE ***

 Next, provide applied resultants, (Nx,Ny,Nxy,Mx,My) and
 (Nx0,Ny0), which are considered to be applied to the panel
 edges. These are stress resultants in units, for example, of
```

lb/in for the in-plane loads Nx,Ny,Nxy and (in-lb)/in for the moment resultants Mx,My:

```
   (Nx, Ny, Nxy, Mx, My) constitute part of Load Set A
                         (eigenvalue loads);
   (Nx0, Ny0   ) are part of Load Set B (fixed and uniform
                 loads).
```

In the absence of normal pressure, the loads corresponding to general instability bifurcation buckling are given by:

```
   Nx(crit) = Nx0(T) +Nx0 + eigenvalue*Factor-of-safety*Nx
   Ny(crit) = Ny0(T) +Ny0 + eigenvalue*Factor-of-safety*Ny
   Nxy(crit) =              eigenvalue*Factor-of-safety*Nxy
   Mx(crit) =               eigenvalue*Factor-of-safety*Mx
   My(crit) =               eigenvalue*Factor-of-safety*My
```

in which Nx0(T) and Ny0(T) are the stress resultants from curing and temperature loading (considered in this example to be part of Load Set B; it is permitted to have them in Load Set A, however).

Also, provide uniform normal pressure, p. The pressure p can be considered either as part of Load Set A or as part of Load Set B. If the pressure is part of Load set B, the loads corresponding to bifurcation buckling are given by:

```
 Nx(crit) = Nx0(T)+Nx0+Nx0(p) + eigenvalue*Factor-of-safety*Nx
 Ny(crit) = Ny0(T)+Ny0+Ny0(p) + eigenvalue*Factor-of-safety*Ny
 Nxy(crit) =                    eigenvalue*Factor-of-safety*Nxy.
 Mx(crit) =                     eigenvalue*Factor-of-safety*Mx
 My(crit) =                     eigenvalue*Factor-of-safety*My
```

in which Nx0(p) and Ny0(p) are stress resultants induced by the normal pressure. (considered in this example to be part of Load Set B; it is permitted to put the pressure in Load Set A, however).

You are allowed to provide up to 5 sets of loads, imperfections, and factors of safety, that is, up to 5 sets of [Nx, Ny, Nxy, Mx, My, Nx0, Ny0, p, Wimp(global), Wimp(local), FSGEN, FSPAN, FSLOC, FSBSTR, FSSTR and temperature distributions].

PANDA2 will generate buckling and stress or strain constraints corresponding to each of the load and imperfection sets that you provide. The resulting design will be the best that PANDA2 can find that is subjected during its mission to all of the load sets. If the panel is clamped in the prebuckling phase, and if there is applied pressure p, then those load sets with non-zero p will each have two subcases, the first corresponding to conditions at the midlength of the panel and the second to conditions at the panel ends. Two subcases are also run for cylindrical panels with rings: Subcase 1 corres- ponds to conditions midway between adjacent rings and Subcase 2 corresponds to conditions at the rings.

For each load set (Nx, Ny, Nxy,....) you will have to provide five "factors of safety", FSGEN, FSPAN, FSLOC, FSBSTR and FSSTR.

FSGEN pertains to general instability (buckling modes which include both rings and stringers); FSPAN pertains to panel instability (buckling modes for which the rings rotate only and for which the stringers deflect; FSLOC pertains to local instability between adjacent rings and stringers; FSBSTR pertains to local buckling of stringer parts. FSLOC and FSBSTR play special roles, so read this carefully! FSSTR is the factor of safety for stress.

FSGEN and FSPAN should always be greater than or equal to unity. The purpose of these two factors is to compensate for initial imperfections and to prevent general instability or panel instability (general buckling between rings). The values you assign these factors depend on the geometry and loading. There is a huge literature on the difficult subject of "imperfection sensitivity". A recent survey is contained in the book, COMPUTERIZED BUCKLING ANALYSIS OF SHELLS by David Bushnell, published by Nijhoff and Co., The Netherlands in 1985. If you assign a factor of 1.0 to FSGEN and/or FSPAN, the factor will automatically be changed by PANDA2 to 1.1 in order to avoid the nearly singular behavior that occurs near general or panel buckling (abrupt increase in bowing amplitude). This singular behavior causes difficulties in convergence of the design during optimization iterations.

Note: During 1993-1994 PANDA2 was upgraded to allow the user to supply amplitudes of the following kinds of initial geometric imperfections in unstiffened and stiffened cylindrical panels and shells:

1. Out-of-roundness
2. General buckling modal imperfection (imperfection has the shape of the critical general buckling mode).
3. Inter-ring buckling modal imperfection (imperfection has the shape of the critical bay buckling mode from a model in which the stringers are smeared out and the panel is simply supported at adjacent rings).
4. Local buckling modal imperfection (imperfection has the shape of the critical local skin buckling mode from a model in which the local piece of skin is simply supported at adjacent stringers and rings).

If the user supplies reasonable amplitudes for these types of imperfections, then he/she may use factors of safety FSGEN and FSPAN of unity, provided that the load corresponds to ULTIMATE load, not operating load.

FSLOC plays a special role. If you do not want local buckling of the panel skin to occur (you don't want any postbuckling capability of the panel skin), then set FSLOC greater than unity, as with FSGEN and FSPAN. With IQUICK = 0, if you set FSLOC = 1.0, PANDA2 will automatically increase it to 1.1.

IF YOU WANT SKIN POSTBUCKLING CAPABILITY, BUT YOU DO NOT WANT LOCAL BUCKLING TO OCCUR AT LESS THAN A CERTAIN FRACTION OF THE APPLIED LOAD, THEN SET FSLOC EQUAL TO THAT FRACTION OF THE LOAD. IF YOU DON'T CARE AT WHAT LOAD LOCAL BUCKLING OCCURS, SET FSLOC EQUAL TO ZERO. PANDA2 WILL THEN ALLOW THE PANEL TO BUCKLE LOCALLY, AND IF IQUICK = 0 WILL INCLUDE POST-LOCAL-BUCKLING PHENOMENA IN CALCULATIONS OF GENERAL AND PANEL INSTABILITY AND STRESS.

The comments for FSLOC apply to the buckling factors of safety for stringer parts FSBSTR, also. You probably will usually set FSBSTR equal to unity.

IF YOU PLAN TO USE A VALUE OF FSBSTR THAT IS LESS THAN UNITY, MAKE SURE THAT YOU READ CAREFULLY ITEMS 37, 60(c), AND 67 IN PANDA2.NEWS.

There is no capability to handle local postbuckling of ring parts.
PANDA2 assigns factors of safety to buckling of ring parts; You
have no control over them.

Now, please provide the first Load Set A (Nx, Ny, Nxy)...

Resultant (e.g. lb/in) normal to the plane of screen, Nx(1)=h

What is wanted is the applied line load in the L1 (axial)
direction in units of force/length. Negative for compression.
If this axial load varies in the L2 (circumferential) direction,
use the largest compressive value applied to that edge of the
panel.

What is wanted now is the axial load in Load Set A, that is
the eigenvalue load: the load to be multiplied by the critical
load factor (the eigenvalue) in computations of the critical
applied load.

```
Resultant (e.g. lb/in) normal to the plane of screen, Nx( 1)=-25000.
 -25000.00
Resultant (e.g. lb/in) in the plane of the screen,    Ny( 1)=-50000.
 -50000.00
In-plane shear in load set A,                        Nxy( 1)=0.
  0.000000
Does the axial load vary in the L2 direction?=h
```

The L2 direction is in the plane of the screen (circum-
ferential). If you answer Y you will next be asked to
provide values of Nx at the beginning and end of the panel
edge which lies in the plane of the screen. PANDA2 assumes
that Nx varies linearly across this edge and is uniform in
the direction normal to the plane of the screen.

NOTE: It may in some cases be beneficial to answer this
question Y and then provide the same Nx at the beginning
and end of the axially loaded edge, thus providing
a uniform axial load. Please see ITEM No.   in PANDA2.NEWS
and read the "handout" entitled "BUCKLING OF UNSTIFFENED
PERFECT AND IMPERFECT UNSTIFFENED CYLINDRICAL SHELLS WITH
PANDA2, dated 25 November, 1988.

If you answer N the axial load will be uniform over the
entire panel.

```
Does the axial load vary in the L2 direction?=n
n
Applied axial moment resultant (e.g. in-lb/in), Mx( 1)=0
        0
Applied hoop moment resultant (e.g. in-lb/in), My( 1)=0
        0
Want to include effect of transverse shear deformation?=h
```

If you answer Y reduction factors are computed for various
kinds of general, semi-general, and local instability and
crippling. These factors reduce the eigenvalues computed
from classical "normals-remain-normal" shell theory. The
reduction factors are based on Timoshenko beam theory. (See
pp 132-136 of Timoshenko and Goodier, 2nd edition.) That is,
a typical reduction factor has the form:

       k = 1/[1 + n*Nx*Lambda/(t*G13)]

in which n is a shape factor (1.2 is now used); Nx is the local stress resultant (lb/in, for example); Lambda is the critical eigenvalue computed from "normals-remain-normal" theory; t is the local effective thickness of the wall; and G13 is the local effective transverse shear stiffness.

```
Want to include effect of transverse shear deformation?=y
y
IQUICK = quick analysis indicator (0 or 1)=h

IQUICK = 0 means discrete BOSOR4-type model will be treated
IQUICK = 1 means only closed-form types of models will be
           included, except for prediction of the static
           response of the entire panel and of the panel module
           to normal pressure.
```

For a panel with stringers almost always use IQUICK = 0
It may be advisable to start out with IQUICK = 1 and to refine the design later with the longer IQUICK = 0 type of analysis. However, don't overdo the IQUICK = 1 option: it might easily lead to unconservative designs! You must use IQUICK = 0 at least once: to check that the design is feasible. You must use IQUICK = 0 if you want to include any effects of local buckling of panel skin or stringer parts.

With TRUSS-CORE SANDWICH construction, it is best to use IQUICK = 1 although IQUICK = 0 is available.

```
IQUICK = quick analysis indicator (0 or 1)=0
        0
Do you want to vary M for minimum local buckling load?=h
```

M is the number of axial half-waves between rings in the local buckling mode.

The developer of PANDA2 always answers "Y". Don't worry about computer time, as described below. That paragraph was written many years ago when computers were much slower.

Computer time can be saved if you are confident that the number of axial halfwaves M that you next choose is truly the critical value for local skin buckling. Generally answer this question Y. Note, however, that there may be cases when you will want to do preliminary optimization runs in which M is fixed at a value that you know is near the critical value for plates with aspect ratios fairly close to that of your current design. In this way you can save a lot of computer time and perhaps come up with a good preliminary optimum design. You can always later allow M to vary, thereby checking your intuition and further improving the design.

```
Do you want to vary M for minimum local buckling load?=y
y
Do you want to choose a starting M for local buckling?=h
```

M is the number of axial halfwaves between rings, or if there are no rings, along the entire axial length of the panel. If you answer N for "no", PANDA2 starts with M calculated from the formula:

```
 M = SQRT(C(5,5)/C(4,4))*(axial length of panel between rings)/
     (stringer spacing - stringer base width) + 2
```

which is based on experimental observations that local buckles of uniformly axially compressed long, narrow, isotropic plates are almost square.

However, from previous experience on this and other similar cases, you may wish to use a different starting value for M. Generally answer this question N for "no".

Do you want to choose a starting M for local buckling?=n
n
Do you want to perform a "low-axial-wavenumber" search?=h

What is being referred to here is a search over the number of axial halfwaves between rings to determine the critical local buckling load factor. There are many panels and loadings for which the local buckling load factor versus the number of axial halfwaves has more than one minimum. If you answer Y, PANDA2 will search for critical local buckling load factors over two ranges of axial halfwaves, a high range and a low range.

The developer of PANDA2 always answers "Y" . Don't worry about computer time. The next paragraph was written when computers were much slower.

Generally, in order to ensure reliability, you should answer this question Y. However, as you gain more experience with PANDA2, you may occasionally want to answer N, since quite a bit of computer time can be saved by doing so, especially if you are doing optimization. You can always do preliminary optimization in which you answer N (no low-wavenumber search), followed by more refined (and more costly) optimization runs in which you answer Y.

Do you want to perform a "low-axial-wavenumber" search?=y
y
Factor of safety for general instability, FSGEN(1)=h

You can use FSGEN = 1.0 if your applied load set corresponds to the ULTIMATE load condition (in constrast to LIMIT load or OPERATING load), and if you specify reasonable ampltiudes for initial imperfections, Wimpg, Wimpg1, Wimpg2, Wpan, Wloc.

If you do NOT specify amplitudes for Wimpg, etc, and/or if the applied load is less than that corresponding to the ULTIMATE condition, then the factor of safety FSGEN should account for unknown initial imperfections and/or insufficient applied load, as well as for the approximate manner in which the general buckling load factor is calculated in PANDA2. Panels that buckle locally at loads far below the design load are not particularly sensitive to initial imperfections. For such panels, use

1.1 <   FSGEN   < 2.0

Panels designed so that local and general instability loads are nearly equal are somewhat sensitive to initial imperfections, and FSGEN should be about 1.4 even if the panel is flat.
Axially stiffened cylinders under axial compression should usually have FSGEN = 2.
Axially compressed monocoque cylinders under axial compression should have FSGEN = 4 if r/t > 300; FSGEN = 2 if r/t < 100.
Cylinders under uniform external pressure should have FSGEN = 1.4.
Cylinders under uniform torsion (in-plane shear) should have FSGEN = 1.3.
NOTE: The above are general guidelines only. For more details, consult the extensive NASA literature, ASME Code Case N-284, and run PANDA with the option to get interaction curves for

```
imperfect shells. Also see COMPUTERIZED BUCKLING ANALYSIS OF
SHELLS by David Bushnell, Nijhoff and Co., The Netherlands, 1985

The best way to design panels with PANDA2 is to use ULTIMATE loads
and to specify reasonable (conservative) amplitudes for the various
components, Wimpg, Wimpg1, Wimpg2, Wpan, Wloc, of imperfections,
then use FSGEN = 1.0.  When you have an optimum design check its
performance by using STAGS.

Occasionally, you may want to use FSGEN = 0.999 . You do this
in order to prevent PANDA2 from automatically increasing FSGEN
to 1.1, which it does if FSGEN = 1.0. For example, you might wamt
to use FSGEN = 0.999 in a case for which you intend to compare
results from PANDA2 with results from some other analysis.

Factor of safety for general instability, FSGEN( 1)=1.
  1.000000
FACTOR OF SAFETY FOR GENERAL INSTABILITY, FSGEN(1),
HAS BEEN CHANGED TO FSGEN = 1.1 TO AVOID SINGULARITY.

Factor of safety for panel (between rings) instability, FSPAN( 1)=h

This factor pertains to buckling between rings but with circum-
ferential wavelengths that are long enough to cause buckling
of at least one stringer.

This factor should account for unknown initial imperfections
and the approximate manner in which the general instability
load factor is calculated in PANDA2.  Panels that buckle
locally at loads far below the design load are not particularly
sensitive to initial imperfections. For such panels, use
              1.1  <   FSPAN    <  1.4
Panels designed so that local and general instability loads are
nearly equal are somewhat sensitive to initial imperfections,
and FSPAN should be about 1.4 even if the panel is flat.
Axially stiffened cylinders under axial compression should
usually have  FSPAN = 2 (except read on about wide column model).
Axially compressed monocoque cylinders under axial compression
should have FSPAN = 4  if r/t > 300; FSPAN = 2 if r/t < 100.
Cylinders under uniform external pressure should have FSPAN = 1.4.
Cylinders under uniform torsion (in-plane shear) should have
FSPAN = 1.3.
If you plan to use the wide column model, you can use a smaller
factor of safety here than would otherwise be the case. In fact,
you can probably get away with using a factor FSPAN = 1.0.
NOTE: The above are general guidelines only. For more details,
consult the extensive NASA literature, ASME Code Case N-284,
and run PANDA with the option to get interaction curves for
imperfect shells. Also see COMPUTERIZED BUCKLING ANALYSIS OF
SHELLS by David Bushnell, Nijhoff and Co., The Netherlands, 1985

Occasionally, you may want to use FSPAN = 0.999 . You do this
in order to prevent PANDA2 from automatically increasing FSPAN
to 1.1, which it does if FSPAN = 1.0. For example, you might wamt
to use FSPAN = 0.999 in a case for which you intend to compare
results from PANDA2 with results from some other analysis.

Factor of safety for panel (between rings) instability, FSPAN( 1)=1.
  1.000000
FACTOR OF SAFETY FOR PANEL INSTABILITY, FSPAN(1),
HAS BEEN CHANGED TO FSPAN = 1.1 TO AVOID SINGULARITY.

Minimum load factor for local buckling (Type H for HELP), FSLOC( 1)=h
```

Local buckling here means buckling of the panel skin between adjacent stringers and rings. The factor FSLOC is NOT included in load factors for local buckling of stringer parts. A different factor, FSBSTR, governs local buckling of stringer parts. Factors of safety for local buckling of ring parts are assigned by PANDA2; you have no control over them.

FSLOC plays a special role. If you do NOT want local buckling to occur (you don't want any postbuckling capability), then set FSLOC greater than unity (minimum of 1.1), as with FSGEN and FSPAN. With the IQUICK = 0 option, PANDA2 assumes the panel between adjacent stringers is flat, so that FSLOC = 1.1 can be used.

If you want postbuckling capability, but you do not want local buckling to occur at less than a certain fraction of the applied load, then set FSLOC equal to that fraction of the load. For example, suppose the load set Nx, Ny, Nxy corresponds to an ultimate load that is 1.5 times the design load. You may not want local buckling to occur below a limit load that is 1.25 times the design load. To enforce this constraint, set FSLOC = 1.25/1.50 = 0.8333. If you are not bothered by local buckling at all, set FSLOC equal to zero.

Occasionally, you may want to use FSLOC = 0.999 . You do this in order to prevent PANDA2 from automatically increasing FSLOC to 1.1, which it does if FSLOC = 1.0. For example, you might wamt to use FSLOC = 0.999 in a case for which you intend to compare results from PANDA2 with results from some other analysis.

```
Minimum load factor for local buckling (Type H for HELP), FSLOC( 1)=1.
  1.000000
FACTOR OF SAFETY FOR LOCAL   INSTABILITY, FSLOC(1),
HAS BEEN CHANGED TO FSLOC = 1.1 TO AVOID SINGULARITY
```

You will next be asked to provide a minimum load factor, FSBSTR, for local buckling of the stringer parts. You should probably use a factor of unity.

If you use a factor less than unity, PANDA2 may produce a design in which one or more of the stringer parts buckle locally at a load smaller than the applied load. Thus, local buckling of the stringer parts would be allowed in your design concept. USE WITH CAUTION!!!

IF YOU PLAN TO USE A VALUE OF FSBSTR THAT IS LESS THAN UNITY, MAKE SURE THAT YOU FIRST READ CAREFULLY ITEMS 37, 60(c), AND 67 IN PANDA2.NEWS.

Also, read items 19 and 30 of PANDA2.NEWS. If the stiffeners are J or T cross sections, a factor of 1.4 is applied to the buckling load factor for buckling of both segments 3 and 4 of the stiffener together. The factor you next apply is in addition to this, so that the total factor is: F.S. = 1.4*FSBSTR.

```
Minimum load factor for stiffener buckling (Type H), FSBSTR( 1)=h
```

Stiffener buckling here means local buckling of the parts of the stiffener, with the "corners" between stiffener parts rotating but not displacing.

IF YOU PLAN TO USE A VALUE OF FSBSTR THAT IS LESS THAN UNITY, MAKE SURE THAT YOU READ CAREFULLY ITEMS 37, 60(c) AND 67 IN PANDA2.NEWS.

FSBSTR plays a special role. If you do NOT want local buckling to occur (you don't want any postbuckling capability of the stiffener parts), then set FSBSTR greater than unity. (Minimum value of 1.1 is suggested.)

The factor of safety for buckling of ring parts is always 1.0 or greater. If you set FSBSTR to a value less than 1.0, your value will be used for buckling of stringer parts, but 1.0 will be used for buckling of ring parts.

If you want postbuckling capability, but you do not want local buckling of the stringer parts to occur at less than a certain fraction of the applied load, then set FSBSTR equal to that fraction of the load. For example, suppose the load set Nx, Ny, Nxy corresponds to an ultimate load that is 1.5 times the design load. You may not want local buckling to occur below a limit load that is 1.25 times the design load. To enforce this constraint, set FSBSTR = 1.25/1.50 = 0.8333. If you are not bothered by local buckling of the stringer parts at all, set FSBSTR equal to zero.

IF YOU PLAN TO USE A VALUE OF FSBSTR THAT IS LESS THAN UNITY, MAKE SURE THAT YOU READ CAREFULLY ITEMS 37, 60(c), AND 67 IN PANDA2.NEWS.

```
Minimum load factor for stiffener buckling (Type H), FSBSTR( 1)=1.
  1.000000
Factor of safety for stress, FSSTR( 1)=h
```

This factor should account for the fact that the theory used to calculate stress, expecially if local buckling of the skin occurs well below the design load, is approximate. The failure criterion is also approximate. Use

$$1.0 < FSSTR < 1.5$$

```
Factor of safety for stress, FSSTR( 1)=1.
  1.000000
Do you want "flat skin" discretized module for local buckling?=h
```

This question refers to the discretized skin-stringer single module model (see for example, Fig. 20(b), p. 524 of the original long PANDA2 paper, PANDA2 - program for minimum weight design... Computers and Structures, vol 25, 469-605, 1987) for local buckling of the panel skin between rings. This discretized module model is used for local buckling if the user-selected analysis control integer, IQUICK = 0 .

Generally, you should answer 'Y', as this will lead to conservative designs. However, there may be times when neglecting the curvature of an axially stiffened cylindrical panel during computations of local buckling of the skin-stringer module leads to results that are too conservative. This would happen, for example, if the stringers were spaced at intervals that are not very small compared to the shell radius.

The default answer is "Y". A "Y" answer generates IICURV = 0 and a "N" answer generates IICURV = 1, in which IICURV is the control index used in PANDA2. (IICURV=0 means "no curvature", 1 means "yes curvature".)

It would be a good idea to optimize panels with this choice taken first one way then the other way.

```
Please see panda2/news Item No. 530 for more information.

Do you want "flat skin" discretized module for local buckling?=n
n
Do you want to skip the KOITER local postbuckling analysis?=h

You answered the previous question "N". Therefore, the index
IICURV = 1 and your PANDA2 discretized single skin-stringer
module model retains the curvature of the cylindrical panel
skin. However, the local postbuckling KOITER theory used in
PANDA2 is still based on the assumption that the skin is flat,
that is, the stringers are close enough together so that it may
not be too conservative to ignore the curvature of the
cylindrical panel. The local postbuckling state is entered
sooner for a skin-stringer panel module with a flat skin than
for one with a curved skin. Therefore, the stresses computed
from the approximate post-local buckling analysis in PANDA2 will
be higher than those of the actual curved panel, provided that
the local buckling load factor for the curved panel is greater
than unity at the design load (no postbuckling occurs for the
curved panel).

If you think that the "flat skin" postbuckling model is too
conservative, then answer "Y" to the current prompt. Then
PANDA2 will skip the KOITER local postbuckling analysis and
compute the stresses as if the amplitude of the local post
buckling deformation is zero.

The default answer is "N". A "N" answer generates IIKOIT = 1 and
a "Y" answer generates IIKOIT = 0, in which IIKOIT is the control
index used in PANDA2. (IIKOIT=0 means "don't perform postbuckling
computations", 1 means "yes, perform postbuckling computations".)

It would be a good idea to optimize panels with this choice
taken first one way then the other way.

******* NOTE ********
If you are planning to do a ITYPE=3 analysis, you MUST
choose a "N" answer here. [ITYPE=3 = fixed design under
increasing load (test simulation)].
***** END NOTE ******

Do you want to skip the KOITER local postbuckling analysis?=y
y
Do you want wide-column buckling to constrain the design?=h

The wide-column model refers to the portion of the panel
between adjacent rings. If there are no rings the wide-column
model refers to the entire panel.

If the portion of the panel between rings is unstiffened or
truss-core sandwich, or isogrid you should always answer N.
For these configurations the wide column model is too conservative.

Otherwise:
If the inter-ring portion is flat you should probably answer Y.
If the panel is cylindrical (curvature in the plane of the
screen) the wide-column buckling load may be too conservative,
leading to unnecessarily heavy designs. If, for a curved panel,
you answer Y, then you will not have to worry as much
about the effect of initial imperfections as you would if you
answer N, because the wide-column buckling load is not
sensitive to initial geomtrical imperfections if there is
```

```
little or no interaction between local and general buckling.
This is a difficult and not very well understood area in the
field of shell buckling. Actually, I recommend that you design
a panel first with use of the wide-column model of general
instability and then without this model.  In any case, check
your general instability load when you finish optimizing by
running PANEL, which sets up a discretized model of the entire
panel width with stringers treated as shell branches. If this
PANEL model has a load factor corresponding to general instability
less than unity, you need either to include the wide-column
model as a constraint or increase the factor of safety.

Do you want wide-column buckling to constrain the design?=n
n

**** WARNING **** WARNING **** WARNING ****
We are now in SUBROUTINE LOADSX: Load Set No.  1
YOU HAVE CHOSEN THAT WIDE-COLUMN BUCKLING WILL NOT
CONSTRAIN THE DESIGN. (THE WIDE-COLUMN MODEL IS ONE IN
WHICH THE PART OF THE PANEL BETWEEN ADJACENT RINGS IS
ASSUMED TO BE FLAT.  UNLESS THE DISTANCE BETWEEN RINGS
IS RATHER LONG OR THE STRINGERS ARE NOT DEEP, WHEN
STRINGERS ARE PRESENT IT IS USUALLY A GOOD IDEA TO
ANSWER "YES" TO THE WIDE-COLUMN QUESTION).

IN ORDER TO AVOID UNCONSERVATIVE DESIGNS, YOU MAY WANT
TO FORCE THE WIDE-COLUMN BUCKLING ANALYSIS TO
CONSTRAIN THE DESIGN SINCE THE PANEL IS STIFFENED BY
STRINGERS. IN YOUR NEXT RUN YOU SHOULD SERIOUSLY
CONSIDER CHANGING YOUR ANSWER TO THE "WIDE-COLUMN"
QUESTION FROM "NO" TO "YES". THIS WARNING IS BASED ON
PREVIOUS EXPERIENCE WITH STRINGER-STIFFENED PANELS.
**** END WARNING **** END WARNING **** END WARNING ***


Next, please provide the fixed stress resultants, Nx0 and Ny0.
These constitute part of the in-plane loads in Load Set B.
Note that no fixed in-plane shear resultant, Nxy0, is permitted.
The fixed stress resultants, Nx0 and Ny0, are not multiplied by
the eigenvalue (eigenvalue = load factor determined in
bifurcation buckling analyses). In the absence of normal pressure,
the critical load can be calculated from:

    Nx(crit) = Nx0(T) +Nx0 + eigenvalue*Factor-of-safety*Nx
    Ny(crit) = Ny0(T) +Ny0 + eigenvalue*Factor-of-safety*Ny
   Nxy(crit) =               eigenvalue*Factor-of-safety*Nxy

in which Nx0(T) and Ny0(T) are resultants generated by curing
and/or temperature (loading) variation from segment to segment
(considered in the above equations to be part of Load Set B;
the thermal loading can be part of Load Set A, however).
Note that the fixed loads are added to any stress resultants
that are generated by thermal loading of a composite panel. The
loads that you are now asked to provide are fixed applied loads.

Resultant (e.g. lb/in) normal to the plane of screen, Nx0( 1)=0
        0
Resultant (e.g. lb/in) in the plane of the screen,    Ny0( 1)=0
        0
Axial load applied along the (0=neutral plane), (1=panel skin)=h

Choose 0 or 1.

0   means that the axial load is applied at the neutral surface,
```

```
    that is, the axial load causes no axial bending of a panel
    with axial stiffeners. The writer almost always uses this
    choice.

1   means that the axial load is applied along the middle
    surface of the panel skin.  A simply supported panel
    with axial stiffeners will bend when loaded in this way.
    PANDA2 includes this axial bending (bowing) effect.

Please use 0 if the panel is clamped. Generally, use 0

Axial load applied along the (0=neutral plane), (1=panel skin)=0
        0
Uniform applied pressure [positive upward. See H(elp)], p( 1)=h

NOTE: This pressure is assumed UNIFORM over entire panel.
Positive pressure always pushes upward.  (Please refer to the
sketches of the panel module for physical picture of what "upward"
means.)  See Fig. 8, p. 490 of Computers and Structures, Vol. 25,
1987. If there are no stringers or if you specified that
the stringers are external, and  if the panel is curved,
then positive (upward) pressure pushes on the concave surface
of the panel (is internal). If you specified that the stringers
are internal and if the panel is curved, then positive (upward)
pressure pushes on the convex surface of the panel. Figure
8 of the PANDA2 paper shows the sign convention for pressure
and curvature.

NOTE: If the panel is curved the value of p must be consistent
      with the value of hoop resultant that you supplied
      earlier (for cylindrical panels Ny=p*r).

Uniform applied pressure [positive upward. See H(elp)], p( 1)=-500.
 -500.0000

THE PANEL IS CURVED: Radius of curvature,        R =  1.0000E+02
INPUT DATA FOR LOAD SET NO.  1:
 NORMAL PRESSURE (positive acting upward),       p = -5.0000E+02
 CURRENTLY APPLIED AXIAL RESULTANTS: Nx(load set A)= -2.5000E+04
                                    Nxo(load set B)=  0.0000E+00
 CURRENTLY APPLIED  HOOP RESULTANTS, Ny(load set A)= -5.0000E+04
                                    Nyo(load set B)=  0.0000E+00

Is the pressure part of Load Set A?=h

Load Set A is the "eigenvalue" load set, that is:

  Critical load = (Load Set B) + eigenvalue*(Load Set A)

If you are concerned with a cylindrical panel or shell and the
pressure is internal (causes tensile membrane loads), then you
should probably put the pressure in Load Set B. If the pressure
is external (causes destabilizing membrane loads), then you
should probably put the pressure in Load Set A.

If the structure is a TRUSS-CORE sandwich construction, make the
pressure part of Load Set A.

Is the pressure part of Load Set A?=y
y
Is the pressure hydrostatic (Type H for "HELP")?=h

Answer Y if you want PANDA2 to print warning about including
the contribution of the pressure to the axial load,
```

```
            Nx = p*r/2  or   Nxo = p*r/2

Is the pressure hydrostatic (Type H for "HELP")?=y
y
Choose in-plane immovable (IFREE=0) or movable (IFREE=1) b.c.( 1)=h

The static response to normal pressure may be strongly dependent
on whether the edges of the panel are allowed to move in the
horizontal direction (in-plane for flat panel), normal to each edge.
IFREE=0 means that this horizontal motion is not allowed. (immovable)
IFREE=1 means that this horizontal motion is allowed.     (  movable)

Generally, you will get larger normal deflections (more bowing)
due to pressure if the edges are movable (IFREE=1). The
membrane strains will be lower and the bending strains will
be higher with movable edges than with immovable edges.

Note that the analysis with IFREE=0 is more rigorous than with
IFREE = 1: With IFREE=0 Newton iterations converge to a nonlinear
solution. The assumed displacements, u,v,w appear as Eqs. (9.5)
in the long PANDA2 paper (Computers and Structures,pp469-605,1987).
With IFREE=1 the same displacement functions are used, but only
the linear theory is used, and the in-plane resultants Nx(p), Ny(p)
are assumed to be zero for a flat panel. (For a curved panel,
Nx(p) is zero and Ny(p) is calculated from the condition that
no horizontal force develops along the straight edges).

Please note that if IFREE = 1, movable edges are permitted only
in the global model of the entire panel under uniform normal
pressure unless you specify otherwise. The IFREE=0 condition is
applied in the local model (single module model) unless you
specify otherwise in the following prompt.

If IFREE = 1, any overall axial resultant that develops from
pressure being applied to the local model is automatically
cancelled by PANDA2's application of an equal and opposite
axial resultant, thus maintaining the condition that no
axial load develops if the edges are free to approach eachother
as the pressure is applied.

If you are in doubt, please just hit "ENTER". Then PANDA2
will supply the default value, which is unity.

Choose in-plane immovable (IFREE=0) or movable (IFREE=1) b.c.( 1)=<enter>
        1
Are you feeling well today (type H)?=h

This question used to read:
   Local model: Are the edges in-plane movable? [See (H)elp]
See ITEM 156 of PANDA2.NEWS for the reason it was modified. A
silly question was added so that people with old cases already
set up would not run into problems upon re-running these cases.

This was the old "help" paragraph corresponding to the original
question:
Answer Y or N. If you answer Y the response of the local
(single-module) model to uniform normal pressure is calculated
from a nonlinear theory in which the two edges normal to the
screen located at the symmetry planes midway between stringers
are allowed to approach eachother as the panel skin deforms
locally under the uniform normal pressure (no in-plane hoop
load develops in the panel skin as it deforms under the pressure).
Generally designs obtained with in-plane movable edges are more
conservative than those obtained with in-plane fixed edges because:
```

(a) the maximum stresses are higher with in-plane movable edges because there is more bending in this case;

(b) No in-plane tension develops in the panel skin with in-plane movable edges which means that local buckling load factors will be lower in this case.

Are you feeling well today (type H)?=<enter>
Y
Is there a maximum allowable deflection due to pressure?=h

Answer Y or N. If your answer is Y, then you will be asked to provide the maximum deflection allowed. A constraint condition will be introduced into the design process. This constraint condition has the form:

WPGMAX/(WPG*AMPLIT) > 1

in which WPGMAX is the maximum allowable deflection, WPG is the normal deflection at the midlength of the panel due to pressure without any effect of in-plane applied loads, and AMPLIT is an amplitude factor that accounts for the softening effect of the in-plane loads. WPG means "normal deflection W due to pressure P from a Global (smeared stiffener) model."

Is there a maximum allowable deflection due to pressure?=n
n

```
****** HYDROSTATIC PRESSURE WARNING **********
INPUT DATA FOR LOAD SET NO.  1:
THE PANEL IS CURVED: Radius of curvature,        R =  1.0000E+02
 NORMAL PRESSURE (positive acting upward),       p = -5.0000E+02
 AXIAL RESULTANT GENERATED BY PRESSURE, Nx = p*r/2 = -2.5000E+04
 Pressure is in Load Set A
 CURRENTLY APPLIED AXIAL RESULTANTS: Nx(load set A)= -2.5000E+04
                                    Nxo(load set B)=  0.0000E+00
MAKE SURE THAT ONE OF THE AXIAL LOADS (Nx or Nxo)
THAT YOU HAVE ALREADY SUPPLIED FOR THIS LOAD CASE
INCLUDES THE COMPONENT p*r/2 GENERATED BY THE
HYDROSTATIC PRESSURE p.
********** END OF HYDROSTATIC PRESSURE WARNING ***********
```

You will next be asked to provide amplitudes for the following modes of initial geometric imperfections
(Wimpg1, Wimpg2, Wpan, Wloc):

(a) overall out-of-roundness amplitude, Wimpg1, where
Wimpg1 = (Max. diameter - Min. diameter)/4.

NOTE: Use zero if the panel is flat. (Wimpg1 will be reset to zero if PANDA2 detects that the panel is flat).

NOTE: If the panel is curved:
Whatever circumferential angle the panel spans, pretend for the purpose of this input datum that it represents part of a complete (360 deg.) cylindrical shell that has an out-of-roundness with amplitude Wimpg1. If Wimpg2 (see next paragraph) is zero, the sign of Wimpg1 is significant. Otherwise, Wimpg1 will have the same sign as Wimpg2 in the calculations in PANDA2.

(b) overall buckling modal imperfection amplitude, Wimpg2.
NOTE: If the panel is stiffened, the sign of the

```
     overall buckling modal imperfection Wimpg2 is important
     because it affects how the panel skin and stiffener
     cross sections of the imperfect panel become loaded
     under the applied loads. Type H(elp) for a discussion
     of this when you are prompted for Wimpg2.

(c) if there are rings, inter-ring buckling modal imperfection
     amplitude, Wpan.  NOTE: The sign of Wpan is important for
     the same reason given in Paragraph (b).

(d) local buckling modal imperfection amplitude, Wloc.
     The sign of Wloc is NOT significant.

Out-of-roundness, Wimpg1=(Max.diameter-Min.diam)/4, Wimpg1( 1)=0.
  0.000000
Initial buckling modal general imperfection amplitude, Wimpg2( 1)=h

In PANDA2 the general imperfection is assumed to have the same
shape as the general buckling mode obtained from a PANDA-type
(closed form) analysis of the cylindrical panel.

IMPORTANT NOTES:
If the panel has axial stiffeners (stringers) and no rings and
if the analysis model IQUICK = 0, then:
  You should consider optimizing with both negative and positive
  Wimpg2. Under axial loading, negative Wimpg2 gives rise to
  more compression in the skin than in the tips of the stringers.
  The opposite is true for positive Wimpg2. You can optimize for
  both positive and negative Wimpg2 by introduction of two load
  cases in MAINSETUP with everything the same in each except the
  sign of Wimpg2.
With IQUICK=1, optimization with both positive and negative
Wimpg2 is automatically performed within a single load case.

If the panel is clamped for buckling, has stringers, and is flat
the effective simply supported length may be less than the actual
length: L(eff) = LENMOD*L, where LENMOD is computed by PANDA2. In
this case, the Wimpg2 that you provide should be given by:
      Wimpg2(your input) = Wimpg2(actual)*2*LENMOD**2
You can obtain LENMOD by running PANDAOPT with ITYPE=2, NPRINT=2
and search the resulting *.OPM file for the string: LENMOD

Initial buckling modal general imperfection amplitude, Wimpg2( 1)=0.5
 0.5000000
Initial buckling modal inter-ring imperfection amplitude,Wpan( 1)=0.
  0.000000
Initial local imperfection amplitude (must be positive), Wloc( 1)=0.
  0.000000
Do you want PANDA2 to change imperfection amplitudes (see H(elp))?( 1)=h

Default is "Y". If you answer "Y" then PANDA2 may automatically
reduce the amplitude of one or more of the buckling modal
imperfections that it judges to be larger than that which would
be easily detectable by the most casual inspection and therefore
greater than that represented by a reasonable tolerance. It was
necessary to allow PANDA2 to do this in order:

(a) to try to avoid extreme oscillations of design margins from
design iteration to iteration, and

(b) to avoid production of optimum designs that are too
conservative.

Since the initial buckling modal imperfections have the unknown
```

shapes of the local, inter-ring, and general buckling modes, the user cannot know ahead of time whether or not a given imperfection amplitude is too large. An imperfection of given amplitude is easier to detect if it has a shape that has short axial and circumferential wavelengths than if it has long wavelengths because it is the wall out-of-plane rotations that are most likely to be detected. These out-of-plane rotations increase inversely with the critical buckling modal wavelengths. The user does not know in advance what the various wavelengths of the critical buckling modes are.

An answer "N" means STRATEGY (1) in [17] is followed.
An answer "Y" means STRATEGY (2) in [17] is followed.

If you answer "Y", PANDA2 will take the following three steps:

Step 1. Use the critical buckling mode shape, (m,n,slope)=(axial halfwaves, circ. halfwaves, nodal line slope) corresponding to the PERFECT rather than the IMPERFECT geometry if the axial halfwavelength of the critical buckling mode of the IMPERFECT geometry is less than or equal to half the user-specified axial halfwavelength of the imperfection.

Step 2. Change the amplitude of whatever imperfection results from Step 1 by the factor (ratio):
(axial halfwavelength of the critical buckling mode)/
(user-specified axial halfwavelength of the imperfection)

Step 3. Reduce the buckling modal imperfection amplitude remaining after Steps 1 and 2 if it leads to an out-of-plane wall rotation that is greater than 0.1 radian. If this happens a warning such as the following (which happens to apply only to the local buckling modal imperfection) will be printed in the *.OPM file:

```
 ******** WARNING ******** WARNING ******** WARNING *********
 THE CIRCUMFERENTIAL HALFWAVELENGTH OF THE LOCAL IMPERFECTION
 Wimp(local), WHICH HAS THE SAME FORM AS THE LOCAL BUCKLING
 MODE, IS SHORT, WHILE ITS AMPLITUDE IS RATHER HIGH:
 Circumferential halfwavelength of Wimp(local),   Wlength=2.97E+01
 Present amplitude of the local imperfection, Wimp(local)=1.67E+00
 PLEASE CONSIDER REDUCING Wimp(local). YOUR DESIGN MAY BE TOO
 CONSERVATIVE.
 ************* END WARNING *********** END WARNING **********
```

The following material printed in the *.OPM file informs the user by what factor the user-supplied imperfection amplitude was reduced in this case in order to keep the maximum out-of-plane wall rotation less than 0.1 rad:

```
 LOCAL AND GLOBAL IMPERFECTION AMPLITUDES,
 AMPLITUDE MODIFIERS THAT KEEP MAX. WALL ROTATION GENERATED
 BY THE MODAL IMPERFECTION COMPONENT LESS THAT 0.1 RADIAN,
 AND AMPLIFICATION FACTORS TO ACCOUNT FOR GROWTH OF THE
 INITIAL IMPERFECTIONS DURING LOADING:
                     USER-PROVIDED   AMPLITUDE   AMPLIFICATION
                     IMPERFECTION    MODIFIER    FACTOR WYYAMP
                       AMPLITUDE      AMPMDi     FROM LOADING
 local imperfection    1.6750E+00    5.4998E-01    1.0182E+00
```

In the above case the local buckling modal imperfection amplitude actually used by PANDA2 is 1.675 x 0.54998 = 0.92122.

You may, however, want to answer the question "N". For example, if you wish to use PANDA2 to evaluate a damaged panel with a known (probably rather large) initial imperfection, you will not want PANDA2 to "take charge" and automatically modify the imperfection amplitude as it did in the above example.

Do you want PANDA2 to change imperfection amplitudes (see H(elp))?(1)= y
y

PANDA2 will next ask you to provide an axial halfwavelength of the general buckling modal imperfection. For axially stiffened panels or panels under external pressure or flat panels, please use the axial length of the panel. PANDA2 uses the axial half-wavelength you give here to change your given amplitude of the general buckling modal imperfection if the axial halfwavelength of the general buckling mode of the perfect shell turns out to be different from that you will next provide here (imperfection amplitude becomes smaller if the axial halfwavelength of the critical buckling mode of the perfect shell is shorter than that you provide here and larger if it is longer than that you will provide here). The purpose of this strategy is to prevent wild swings in margins corresponding to small changes in design caused by abruptly different critical general buckling mode shapes. Please see [17] and ITEM NO. 525 of ...panda2/doc/panda2.news for more details.

Axial halfwavelength of typical general buckling mode, AXLWAV(1)=300.
  300.0000
Do you want PANDA2 to find the general imperfection shape?(1)=h

Almost always answer Y (yes). PANDA2 will then find the (m,n,slope) for the general buckling mode, in which
m = number of axial halfwaves
n = number of circumferential halfwaves
s = slope of the buckling nodal lines.
The imperfection shape is assumed to be the same as the general buckling mode shape.

If you for some reason should answer N (no), then you must next supply values of (m,n), called MUSER and NUSER. In the section of PANDA2 that computes general buckling imperfection sensitivity, PANDA2 will not search over (m,n) space to find the critical general buckling modal imperfection shape, but instead will use only the values (MUSER,NUSER) that you will next supply. PANDA2 will continue to search over "s-space" (s = slope of buckling nodal lines) for a minimum general buckling load factor with respect to s for given and fixed (m,n) = (MUSER, NUSER).

Do you want PANDA2 to find the general imperfection shape?(1)=y
y

IF THE LOCAL IMPERFECTION IS LESS THAN OR EQUAL TO ZERO, IT WILL BE SET EQUAL TO (1/10)TH OF THE THICKNESS OF THE SKIN MIDWAY BETWEEN STRINGERS. THIS IS DONE TO MAKE THE VARIATION OF STIFFNESS IN THE NEIGHBORHOOD OF THE LOCAL BUCKLING LOAD SMOOTHER, WHICH RESULTS IN BETTER BEHAVIOR DURING OPTIMIZATION CYCLES.

Maximum allowable average axial strain (type H for HELP)(1)=h

This input permits you to account for strain (stress) concentrations near bolt holes. Use a value such that if this value were reached along axial lines of fasteners, there would be no failure because of the fasteners. This allowable is placed in the load loop because you may want to provide different values for tension and compression.

A factor of safety of unity is used in PANDA2 for this allowable. Also, the margin is calculated using only the axial strain component, EXAVE. The concept of effective strain resulting from the three in-plane strain components, EXAVE, EYAVE and EXYAVE, is not used. Therefore, you must set the maximum allowable average axial strain small enough to yield a reliable design.

If you are not concerned with this, just type zero or a large number. Use a positive number. Units are strain, not percent.

```
Maximum allowable average axial strain (type H for HELP)( 1)=1.
 1.000000
Is there any thermal "loading" in this load set (Y/N)?=h
```

What is meant is thermal loading other than curing. Usually, you answer N. If there is aerodynamic heating or other source of heating which may be significant in your case, answer Y. If you answer Y, you will be asked to provide two temperatures for the panel skin (corresponding to the uppermost and lowermost surfaces of the panel skin and stringer/ring bases) and one temperature each for the outstanding stringer flange and outstanding ring flange. (With blade stiffening, you will be asked to provide the temperature at the blade tip). The temperatures you will provide are assumed to be uniform over each segment of the panel module except as follows:

1. the panel skin and stringer and ring bases, in which the temperature is assumed to vary linearly through the thickness, except in the case of truss-core for which the temperature in the panel skin is constant through the thicknesses of each of the two face sheets (different in the two sheets, though).

2. the stiffener webs, in which the temperature is assumed to vary linearly from the web root to the web tip. At the web root the web temperature is the same as that of the panel skin at that point. At the web tip the web temperature is assumed to be the same as that of the outstanding flange.

```
Is there any thermal "loading" in this load set (Y/N)?=n
n
```

Next, you will be asked, "Do you want a complete analysis?" Usually you should respond Y (or just hit "ENTER"). This question refers to analysis with stress and buckling constraints generated from both Subcase 1 (midlength or midbay) and Subcase 2 (panel ends or at rings). (Note that for some loadings the "complete" analysis has only a single subcase, Subcase 1. Then your response to this question, although required, will not matter). Ordinarily you will want the panel to be optimized accounting both for the behavior at its midlength (midbay) and at its ends (at rings). However, there are doubtless cases for which this conservative approach may generate overly heavy panels. For example, there may exist rather local stress concentrations in the panel skin and local buckling of the panel skin only in the neighborhoods of rings in a curved panel or at the ends of a clamped curved or flat panel with applied pressure. The use of a "complete" analysis might then cause the panel skin to be overly thick over most of the panel length in order that it not buckle due to local compressive resultants present only near rings (or at ends). The best design might well be a panel the skin of which is thinner midway between rings than near rings. The skin near rings would be thickened locally to reduce stress and prevent local buckling there. Since PANDA2 does not handle axially varying thickness or stringer cross section directly, you might want to perform two sequential optimizations, the first in which you do the "complete" analysis in order to ensure that the worst conditions generated by both Subcases 1 and 2 are included, and the second in which only the conditions for Subcase 1 constrain the design. Before doing the second optimization, you might have to rerun DECIDE in order to eliminate the stringer and ring spacings and perhaps the stringer cross section dimensions as decision variables, and to reset lower bounds on stringer and ring thicknesses and perhaps web heights and flange widths to the values obtained from the first optimization. This you might need to do to ensure that the final design can be fabricated and that it will survive the conditions at Subcase 2, which is not checked during the second optimization. Both the first optimum design (from the "complete" analysis) and the second optimum design (from the "Subcase 1 only" analysis) you would incorporate into the actual panel during manufacture: the panel skin and stringer dimensions from the first optimum design would be used for a certain axial length of panel near the rings, and the panel skin and stringer dimensions and ring dimensions from the second optimum design would be used for the panel midlength (or midbay) region and for the rings. You would have to specify the axial extent of each of the two regions. Unfortunately, PANDA2 cannot do this for you. You will have to rely on engineering judgment. If you use PANDA2 this way to generate designs that are really beyond the straightforward scope of PANDA2, it is especially important for you to apply some general-purpose finite element code such as STAGS to verify the feasiblility of your fancy hybrid optimum design before you actually fabricate the panel. SEE ITEM 175 IN PANDA2.NEWS FOR MORE INFORMATION AND AN EXAMPLE.

```
Do you want a "complete" analysis (type H for "Help")?=y
y
Want to provide another load set ?=n
n

IMPOSE TOTAL THICKNESS LIMITS FOR THE SEGMENTS OF AN
X-ORIENTED CROSS-SECTION OF THE PANEL MODULE:

Do you want to impose minimum TOTAL thickness of any segment?=n
n
Do you want to impose maximum TOTAL thickness of any segment?=n
n

IMPOSE TOTAL THICKNESS LIMITS FOR THE SEGMENTS OF A
RING CROSS-SECTION:

Do you want to impose minimum TOTAL thickness of any segment?=n
n
Do you want to impose maximum TOTAL thickness of any segment?=n
n
Use reduced effective stiffness in panel skin (H(elp), Y or N)?=h
```

Generally answer Y in order to avoid unconservative designs. However, occasionally you may want to answer N in order to avoid too much conservativeness for cases for which you believe the panel skin is fully effective for overall bending of the panel.

You should answer Y if you panel has any local initial imperfection.

If the panel skin is permitted to buckle locally, that is, if the factor of safety for local buckling, FSLOC, is significantly less than unity (e.g. FSLOC < 0.9) then you should always answer Y.

A "N" answer may be suitable for panels in which the stringer spacing b is about the same as the stringer height h or width w, such as may be the case for hat-stiffened panels with closely pitched corrugated skin or for truss-core panels, provided that local buckling of the panel skin is not permitted to occur.

If you answer Y to this question, reduced membrane stiffnesses C11, C12, C22, and C33 are used for the panel skin segments for calculation of overall bending of the panel under uniform pressure and for predictions of general instability load factors that are used for determination of amplification of axial bowing.

```
Use reduced effective stiffness in panel skin (H(elp), Y or N)?=y
y
NPRINT= output index (-1=min. 0=good, 1=ok, 2=more, 3=too much)=h
```

Usually use 0 . NPRINT = 0 is recommended for optimization analyses, since these analyses produce another useful file, NAME.OPP, which contains the entire design history and is much easier to read than the NAME.OPM file. The new plotting capability CHOOSEPLOT/DIPLOT, also makes it less necessary to generate lots of printed output. NPRINT = 3 really gets alot of output. NPRINT = 2 yields the C(i,j), the force distributions in the various parts of the panel module, local buckling modal displacements, and resdistributed loads due to bowing and local postbuckling behavior. Do not use 2 if you are doing an optimization analysis. When you use 0, please make sure to consult the NAME.OPP file (optimization, ITYPE= 1), or the NAME.OPI file (test simulation, ITYPE = 3), for more information. NPRINT = -1 leads to minimal output (margins and design only.

The developer of PANDA2 generally uses NPRINT = 0 for optimization runs (ITYPE=1) and NPRINT = 2 for the analysis of a fixed design (ITYPE = 2). NPRINT = 2 generates a large *.OPM file, but you can find what you want by searching for the strings, "CHAPTER" or "MARGINS" or "WEIGHT".

On rare occasions you may want to use NPRINT = 2 with ITYPE = 1 . When you do this PANDA2 prints out details pertaining to each CHAPTER, both for the current design and for the perturbed designs, then prints out the matrix of contraint gradients, then is that PANDA2 computes the constraint gradient matrix and then aborts. You may want to set NPRINT = 2 with ITYPE = 1 in a case for which you suspect that there is a bug in the program or perhaps in your input data. You can inspect the constraint gradient matrix to see if there are any very large gradients that might have been generated because of a bug. Then you will want to inspect the results for the current and for the perturbed designs in an attempt to determine the cause or causes of the overly large constraint gradients.

```
NPRINT= output index (-1=min. 0=good, 1=ok, 2=more, 3=too much)=0
        0
```

Next, you will be asked to provide an index, ISAND, for the type of shell theory to be used in the PANDA-type (closed form) buckling analysis. You can choose either ISAND = 0 or ISAND = 1 or ISAND = 2:

ISAND = 0 means that Donnell theory will be used (corrected for
           "live" pressure that effects primarily n = 2 and n = 3

buckling load factors of cylindrical shells)
ISAND = 1 means that Sanders' theory will be used. (ITEMs 128,410)
ISAND = 2 means that Marlowe's theory will be used. (ITEM 411)
The Donnell theory kinematic and "work done" terms are appear in Eqs (53) and (49b) on p 552 of Vol. 27 of Computers and Structures (1987 - "Theoretical basis of the PANDA......", with modifications described in ITEM 68 of the file PANDA2.NEWS.
The Sanders theory is described in ITEMs 128, 410 of PANDA2.NEWS.
The Marlowe theory is described in ITEM 411 of PANDA2.NEWS.

The developer of PANDA2 now almost always uses ISAND = 1 . Don't worry about computer time. Computers run much faster now than they did when the following paragraph was written.

You should always first do optimization first with ISAND = 0.
On the last iteration for each "PANDAOPT", PANDA2 automatically checks buckling load factors with ISAND = 1 when the user provides ISAND = 0 in MAINSETUP. If results from these "last" iterations are significantly different from those corresponding to ISAND = 0, then the optimization must be run with ISAND = 1 or 2. ISAND = 1 or 2 requires much more computer time than does ISAND = 0. Results from ISAND = 2 are rarely different from those from ISAND = 1.

Index for type of shell theory (0 or 1 or 2), ISAND=h

ISAND = 0 means Donnell theory is used (with appropriate correction for "live" pressure effect)
ISAND = 1 means Sanders theory is used (See PANDA2.NEWS ITEM 128, 410 for details).
ISAND = 2 means Marlowe theory is used (see PANDA2.NEWS ITEM 411 for details).

The developer of PANDA2 now almost always uses ISAND = 1 . Don't worry about computer time. Computers run much faster now than they did when the following paragraph was written.

Generally use ISAND = 0, as it runs much faster on the computer.
In optimization runs (ITYPE=1) in which ISAND = 0, PANDA2 automatically checks margins with use of ISAND = 1 after the last design iteration in the current set of design iterations. If you use ISAND = 0, check the end of the *.OPM file to see if there are any significantly negative margins generated from the buckling analyses in which ISAND = 1. If so, then do optimization with ISAND = 1 or 2. You will rarely, if ever, need to use ISAND = 2, since for practical panels the Sanders and Marlowe theories give essentially the same results.

Index for type of shell theory (0 or 1 or 2), ISAND=1
1

Next, you will be asked:
"Does the postbuckling axial wavelength of local buckles change?"
What is meant is: "Does the postbuckling axial wavelength of local buckles change continuously as the applied load is increased above the load which causes initial local buckling of the panel skin between rings and stringers?"

Just hit "Enter" if you don't know. The question is relevant only for analyses with IQUICK = 0, as it applies only to the postbuckling analysis, which is based on the discretized single panel module model. The default is "Y", and in practically all cases you should answer "Y" (or hit "Enter", which has the same effect). You should always answer "Y" if this run is to be an optimization run.

You might want to answer "N" if your purpose in using PANDA2 is to generate post-local-buckling 3x3 tangent stiffness matrices to be compared with results from STAGS or some other general-purpose finite element computer code. In panels with the ratio of ring spacing to stringer spacing less than about 5 or 6, the axial wavelength of local buckling of the skin often stays constant for a rather large range in load above the initial local buckling load, especially in cases where axial compression Nx predominates and the applied in-plane shear load Nxy is small.

Does the postbuckling axial wavelength of local buckles change?=<enter>
Y

Next, you will be asked, "Want to suppress general buckling mode with many axial waves?"

You should usually answer N. Your answer affects the results only for ring-stiffened cylindrical panels subjected to external pressure. In such cases there may be two types of general buckling (buckling of skin and stiffeners together):

(1) general buckling in a mode with one axial halfwave.
(2) general buckling in a mode with many axial halfwaves.

If you answer Y, PANDA2 may set up a constraint condition that forces Mode Type (2) to have a load factor that is at least 5 per cent higher than that associated with Mode Type (1). NOTE: THIS SPECIAL DESIGN CONSTRAINT SOMETIMES CAUSES THE DESIGN TO DRIFT AWAY FROM THE OPTIMUM CONFIGURATION. THEREFORE ANSWER "Y" ONLY IF YOU HAVE FIRST FOUND AN OPTIMUM WITH A "N" ANSWER. Answer H(elp) for further explanation, in particular. under what loading conditions the "many-axial-halfwave" buckling mode is to be suppressed.

Want to suppress general buckling mode with many axial waves?=h

Both types of buckling modes generally have several halfwaves over the circumference of the cylindrical (deep) panel or shell. Depending on the spacing and depth of the rings, either of these modes might be critical. If you answer N, PANDA2 will accept whichever type of general instability mode corresponds to the lowest general instability load factor. If you answer Y, PANDA2 will set up a constraint condition that forces the general buckling load factor associated with the mode type (2) to be at least 5 per cent higher than that associated with the mode type (1). This special constraint condition may make it difficult to settle on the best optimum: With successive PANDAOPTs, the designs, while feasible, may drift away from previously found configurations that weigh less. Therefore, it is best to start by answering N, finding an optimum design, then anwering Y and continuing, then returning to answering N again and doing more PANDAOPTs. NOTE: If you answer "Y", you may want to do a series of optimizations with fixed ring spacing. (Eliminate the ring spacing as a decision variable.)

More on this item: A control integer IHIAXL equals 0 if the user answers "N" and IHIAXL = 1 if the user answers "Y". ILAMHI is another control integer that depends on the value of IHIAXL and on a third integer, IMLOC, to be explained next. ILAMHI is initially set equal to zero, and IMLOC is initially set equal to unity.

IMLOC is a switch that determines whether or not general buckling load factors are to be saved corresponding to both low and high numbers of axial halfwaves in the buckling mode. If yes, then IMLOC = 0. If IHIAXL and ILAMHI are both unity (IHIAXL is a user-supplied index and ILAMHI, initially zero, is possibly reset later), a constraint condition is set up by means of which the buckling load factor associated with the general buckling mode with the high number of axial halfwaves is forced to be at least 5 per cent higher than that associated with the general buckling mode with thelow number of axial halfwaves.

In order for IMLOC to be set to zero, the norm of the applied axial and hoop stress resultants, sqrt(Nx^2 + Ny^2), must be greater than ten times the applied in-plane shear resultant Nxy, the hoop resultant Ny must by greater than 1.9 times the axial resultant Nx, and both Nx and Ny must be negative (compressive loading).

Want to suppress general buckling mode with many axial waves?=<enter>
Y

Next, you will be asked, "Do you want to double-check PANDA-type eigenvalues?" Please answer H for HELP if you are not familiar with this prompt.

This double-check can take lots of computer time. Generally answer N if the panel is flat. Generally answer N if you plan to do optimization (ITYPE=1) or test simulation (ITYPE=3). Generally answer N if you are including transverse shear deformation effects: LOTS of computer time is required!

The "double-check" very rarely has any effect on the results. However, if you are running an ITYPE=2 (fixed design) analysis for a final design configuration of a curved panel, you might answer Y.

Do you want to double-check PANDA-type eigenvalues [type (H)elp]?=h

This double-check can take lots of computer time. Generally answer N if the panel is flat. Generally answer N if you plan to do optimization (ITYPE=1) or test simulation (ITYPE=3). Generally answer N if you are including transverse shear deformation effects: LOTS of computer time is required! Generally answer Y if you are analyzing a fixed design of a curved panel in which in-plane shear loading is present and you are neglecting transverse shear deformation effects. Answer N if you are not near an optimum design. If you are near an optimum, or if you are suspicious of the load factors from the PANDA-type (closed form) analysis, answer Y. If you answer Y and if there is in-plane shear loading or anisotropic terms in the C(i,j) matrix (constitutive law), then PANDA2 will check the minimum buckling load factors obtained by an initial (partial) search in slope space (slope of the nodal lines in the buckling mode shape) by calculating eigenvalues over a range of nodal line slopes from zero to 10.0 for every wavenumber combination (m,n). This extra search takes more computer time, of course, so it shouldn't be done unless you feel you are near an optimum design or you doubt the PANDA-type eigenvalues. (There is a partial double-check even if you answer N).

Do you want to double-check PANDA-type eigenvalues [type (H)elp]?=<enter>
N

Next you will be asked to make a choice between two variations of the local postbuckling theory to be applied in your runs:

```
 (0) "transverse inextensional"       (0 is the preferred option)
 (1) "transverse extensional"

The 0 option is preferred because it leads to more conservative
designs and generally seems to agree better with test results,
especially with regard to prediction of the number of axial
halfwaves in the postbuckling regime. Also, the nonlinear
equations governing the postbuckled state converge more reliably.

The "transverse extensional" theory may agree better with
tests and other analyses if the edges of the panel normal to the
screen cannot deform in the plane of the panel (deform in the
y-direction, that is, the direction in the plane of the panel
and normal to the edges that run parallel to the stringers).
However, Newton method fails to converge more often than is
the case for the "inextensional" theory.

The "transverse inextensional" theory is most appropriate if the
edges of the panel normal to the screen are free to deform in the
plane of the panel. This theory is generally conservative, as it
leads to the prediction of local buckles with larger amplitudes.

NOTE:  The projections of the two longitudinal edges (edges normal
       to the screen) onto the surface of the undeformed panel are
       ALWAYS free to move in the y-direction as straight lines.

Choose (0=transverse inextensional; 1=transverse extensional)=<enter>
        1
Choose ICONSV = -1 or 0 or 1 or H(elp), ICONSV=h

Please use ICONSV = 1 as the preferred choice.

ICONSV = 1 (recommended model) means:
  a. Include ARBOCZ theory when computing knockdown
     factors for local, inter-ring, general buckling.

  b. Use more conservative knockdown factors for models
     in which the stringers are smeared.

  c. Use computed knockdown factor for smearing rings

  d. The Donnell shell theory is used in SUBROUTINE STRIMP,
     where imperfection sensitivity is being computed.

  e. Will use the non-zero slope of buckling nodal lines
     in the computation of prebuckling bending and
     twisting, Wxx, Wyy, Wxy, of shells with general,
     inter-ring, and local buckling modal imperfections.
     (panda2.news Items 620 and 645 are cancelled).

ICONSV = 0 (less conservative model) means:
  a. Do NOT include ARBOCZ theory when computing knockdown
     factors for local, inter-ring, general buckling.

  b. Use less conservative knockdown factors for models
     in which the stringers are smeared.

  c. Use computed knockdown factor for smearing rings
     (Same as for ICONSV = 1).

  d. The user-selected shell theory is used in SUBROUTINE
     STRIMP, where imperfection sensitivity is being
     computed.
```

e. panda2.news Items 620 and 645 are cancelled. (Same as for e. under ICONSV = 1).

ICONSV = -1 (still less conservative model) means:

a. Do NOT include ARBOCZ theory when computing knockdown factors for local, inter-ring, general buckling. (Same as for ICONSV = 0)

b. Use less conservative knockdown factors for models in which the stringers are smeared. (Same as for ICONSV = 0)

c. Do NOT use computed knockdown factor for smearing rings (Knockdown factor for smearing rings = 1.0 EXCEPT when there exists significant local deformation in the outstanding flange of the ring in the "skin"-ring single discretized module general buckling model, in which case the knockdown factor is computed in the same way as for ICONSV = 1 and ICONSV = 0).

d. Set the knockdown factor for truncated double-trig series expansion (altsol) models to RFACT = 0.95. (RFACT=0.85 for "altsol" models in which there are smeared stiffeners if ICONSV = 0 or 1).

e. The user-selected shell theory is used in SUBROUTINE STRIMP, where imperfection sensitivity is being computed.

f. panda2.news Items 620 and 645 are in force, that is, a non-zero slope of buckling nodal lines will probably be set to zero for the computation of Wxx, Wyy, and Wxy. (Different from e. under ICONSV = 0 and ICONSV = 1).

g. panda2.news Item 741 is in force, that is, the "effective" buckling load for the imperfect shell is given by:

```
       FMULT2 = 1.0
       IF (ICONSV.EQ.-1) FMULT2 = 10.0
       EIGEFF =(FACIM1*EILOC9 +FACIM2*FMULT2*EILC91)/
                                (FACIM1+FMULT2*FACIM2)
```

for general buckling, and

```
       FMULT2 = 1.0
       IF (ICONSV.EQ.-1) FMULT2 = 10.0
       EIGEFF =(FACIM1*EILOC8 +FACIM2*FMULT2*EILC81)/
                                (FACIM1+FMULT2*FACIM2)
```

for inter-ring buckling, and

```
       FMULT2 = 1.0
       IF (ICONSV.EQ.-1) FMULT2 = 10.0
       EIGEFF =(FACIM1*EILOC7 +FACIM2*FMULT2*EILC71)/
                                (FACIM1+FMULT2*FACIM2)
```

for local buckling, in which EILOC9, EILOC8, EILOC7 are buckling load factors for the imperfect shell, and EILOC91, EILOC81, EILOC71 are buckling load factors for the perfect shell. The factors, FACIM1 and FACIM2, are given by:

FACIM1=1./(EILOC9 - 1.) and FACIM2=1./(EILOC91 - 1.) for general buckling,

```
     FACIM1=1./(EILOC8 - 1.) and FACIM2=1./(EILOC81 - 1.)
     for inter-ring buckling, and

     FACIM1=1./(EILOC7 - 1.) and FACIM2=1./(EILOC71 - 1.)
     for local buckling.

Choose ICONSV = -1 or 0 or 1 or H(elp), ICONSV=<enter>
        1
Choose type of analysis (ITYPE = 1 or 2 or 3 or 4 or 5)=h

1  means an optimization analysis will be performed.
   Make sure that you have chosen decision variables, linked
   variables, geometrical inequality constraints, and escape
   variables via DECIDE.

2  means PANDA2 will perform a buckling/stress analysis of a
   fixed design for up to 5 load sets.

3  means PANDA2 will simulate a test of a panel with fixed
   design: For one of the load sets the behavior of the panel
   under monotonically increasing loads will be investigated.
   Note that this option requires that IQUICK = 0 for that
   load set which is selected by the user. Also, the KOITER
   branch MUST be entered. (IIKOIT=1)

4  means that margins will be calculated for all design
   variables fixed except one user-selected variable. Margins
   will be calculated for a sequence of designs in which the
   user-selected variable is incremented from a user-selected
   starting value to a user-selected ending value.

5  means that margins and interaction curves will be calculated
   for a user-selected in-plane load combination:
       (N1,N2) = (Nx,Ny) or (Nx,Nxy) or (Ny,Nxy)
   for a user-selected number of values of N1 and N2.

Choose type of analysis (ITYPE = 1 or 2 or 3 or 4 or 5)=1
        1
Do you want to prevent secondary buckling (mode jumping)?=h

"Secondary Buckling" means mode jumping, or post-post-local buckling.
Mode jumping is initiated by local bifurcation buckling in a panel
skin which has already been loaded well beyond initial local buckling.
Mode jumping might cause material failure, especially for composite
walls that delaminate relatively easily.

Example of secondary buckling: Suppose you have an axially stiffened
panel under pure axial compression.  For axial loads well above that
corresponding to local buckling of the panel skin between stringers
the internal axial resultant Nx in the skin becomes concentrated near
the stringers. The question is, under the redistributed Nx does local
bifurcation buckling occur for a load factor less than unity? If so,
then mode jumping is possible.

NOTE: Your panel may become a lot heavier if you elect to prevent
      mode jumping. It may be a good idea to obtain optimum designs
      both with Y and N answers to this question. See the papers,
      AIAA-97-1141: "Optimization of stiffened panels in which
      mode jumping is accounted for" (1997 SDM Meeting), and
      AIAA-98-1990: "Optimization of panels with riveted z-shpaed
      stiffeners via PANDA2 (1998 SDM Meeting) for some guidance.

Do you want to prevent secondary buckling (mode jumping)?=<enter>
```

```
Y
Do you want to use the "alternative" buckling solution?=h

The "alternative" buckling solution is more accurate but uses
much more computer time than the "regular" solution. The "regular"
solution is the PANDA-type closed form solution obtained from the
assumed displacement field given by Eqs. (50) in the paper,
"Theoretical basis...", Computers and Structures, Vol. 27,
pp 541-563, 1987, leading to Eq. (57) on p. 553 of that paper. The
"alternative" solution is obtained via double-trig series
expansions for buckling modal displacement components,  u, v, w.
It is described in detail in ITEM 438 of ...panda2/doc/panda2.news.

SUGGESTION: Start optimization by answering "N". Then finalize
with use of the answer "Y".

Do you want to use the "alternative" buckling solution?=<enter>
N


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.

How many design iterations permitted in this run (5 to 25)?=h

Choose a number between 5 and 25, usually 5 to 8.
If the design margins seem to jump around quite a
bit, or if the weight cycles from iteration set to
iteration set, use a high number of iterations (20 or 25).

How many design iterations permitted in this run (5 to 25)?=5
        5
MAXMAR. Plot only those margins less than MAXMAR (Type H)=h

Choose a number between  1  and  10.  1 to 5 is best.
Every time you give the command PANDAOPT the results from
the design iterations associated with the resulting batch
run are stored in a binary file called NAME.PL1, in which
NAME is your chosen name for the case. These results are
re-organized in a processor called STORE and added to
similarly re-organized results from previous PANDAOPT
runs for the same case.  If MAXMAR is too large, you may
be swamped with data (for example, hundreds of stress
margins generated for multilayered composite panels)
that you don't really need to see.  Try MAXMAR = 1 to 5.
The bigger the case (more variables, more load sets, more
iterations) the smaller MAXMAR should be. Note that MAXMAR
```

```
must be greater than or equal to 1.

MAXMAR. Plot only those margins less than MAXMAR (Type H)=<enter>
  1.000000
Do you want to reset total iterations to zero (Type H)?=h

PANDA2 accumulates results from all iterations from the
start of the case. These results can be plotted via the
processors CHOOSEPLOT and DIPLOT.  It is possible that
you may no longer want to plot results from previous runs;
you may want to make a "fresh" start, but with use of the
current design state rather than the original design
state from the NAME.BEG file.  You can do this by answering
Y to this question.  Then ITRTOT will be set to zero.
Likely occasions to reset ITRTOT to zero are:
1. If you started from a very bad design state;
2. If you are changing IQUICK, the integer that points to
   the type of analysis that you are doing;
3. If you are changing one or more load sets or edge
   conditions.
4. If you already have lots of iterations and plotting is
   too time consuming.

Do you want to reset total iterations to zero (Type H)?=<enter>
N
Index for objective (1=min. weight, 2=min. distortion)=h

1 means that PANDA2 will find the minimum weight of the panel.
  You must have previously assigned non-zero density to at
  least one part of the panel.

2 means that PANDA2 will find the minimum distortion of the
  panel due to uniform temperature changes.  To use this option,
  you must have previously assigned non-zero coefficient of thermal
  expansion to at least one part of the panel, and you must have
  assigned nonzero curing temperature to all parts of the panel
  that have nonzero coefficients of thermal expansion. This curing
  temperature should be the same in all these parts. PANDA2
  minimizes the quantity

       DISTORTION=SQRT{ ET1**2 +ET2**2
                      +[TEFF(1)*ET4]**2 +[TEFF(2)*ET5]**2 }

  in which ET1, ET2, ET4, ET5 are the thermal strains and
  changes in curvature due to curing for the panel with smeared
  stiffeners and TEFF(1) and TEFF(2) are the effective thicknesses
  of the panel with smeared stiffeners in the axial and circ.
  coordinate directions, respectively.

Index for objective (1=min. weight, 2=min. distortion)=<enter>
        1
FMARG (Skip load case with min. margin greater than FMARG)=h

Generally use FMARG > 0.5. FMARG must be greater than 0.1.
If you have an optimization problem with many load sets, and
a lot of computer time is required for design iterations,
you might want to set FMARG to a number as low as 0.2 or even,
in extremely long-running cases, to a number as small as 0.11.

You should have as the first load case that which is most
likely to generate the most critical design margins.

In the first design iteration of each PANDAOPT, PANDA2 will
explore all of the load cases and subcases. The test for possible
```

```
 elimination of a load subcase is applied only after completion
 of all calculations for the first design iteration. If the
 test on minimum margin for a load subcase indicates that that
 subcase should be skipped, it will be skipped for all remaining
 design iterations in the current PANDAOPT except the last,
 during which calculations for that load subcase are reintroduced.
 If that last iteration shows any negative margins, you must
 raise the value of FMARG before executing PANDAOPT again.
 Otherwise, the design that evolves will have negative margins.

 FMARG (Skip load case with min. margin greater than FMARG)=<enter>
   1.000000


 DESCRIPTION OF FILES GENERATED BY THIS CASE:

 cylstif.OPT = Summary of interactive session you have just
          completed. This file can be edited and used for
          future runs of MAINSETUP.

 cylstif.CBL = Contains part of cylstif data base.

 cylstif.OPM = Output from MAINSETUP. Please list this file and
          inspect it and the cylstif.OPT file carefully before
          proceeding. (NOTE: The cylstif.OPM file will be empty
          unless the session just finished was a tutorial.)

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

 Next, give the command CHOOSETEMP or PANDAOPT or SUPEROPT.


 IN ORDER TO AVOID FALSE CONVERGENCE OF THE DESIGN, BE SURE TO
 RUN  PANDAOPT  MANY TIMES DURING AN OPTIMIZATION. INSPECT THE
 cylstif.OPP  FILE AFTER EACH OPTIMIZATION RUN. OR BETTER YET,
 RUN SUPEROPT.
 **** NOTE: It is almost always best to set the number of ****
 **** iterations per execution of "PANDAOPT" equal to 5   ****
 **** in response to the following prompt in "MAINSETUP": ****
 "How many design iterations permitted in this run (5 to 25)?"
 **** Hence, the *.OPT file should almost always have the ****
 **** following line in it:                               ****
 "5   $ How many design iterations in this run (5 to 25)?"

-------------- end of "MAINSETUP" interactive session --------------

The files now existing in the working directory are the following:

-rw-r--r--   1 bush bush     76 Feb 21 12:44 cylstif.010
-rw-r--r--   1 bush bush   2046 Feb 21 11:27 cylstif.AL2
-rw-r--r--   1 bush bush   2058 Feb 21 11:27 cylstif.AL3
-rw-r--r--   1 bush bush   2058 Feb 21 11:27 cylstif.ALL
-rw-r--r--   1 bush bush   5604 Feb 21 11:18 cylstif.BEG
-rw-r--r--   1 bush bush 110324 Feb 21 11:27 cylstif.BL1
-rw-r--r--   1 bush bush 110324 Feb 21 11:27 cylstif.BL2
-rw-r--r--   1 bush bush 110324 Feb 21 11:27 cylstif.BL3
-rw-r--r--   1 bush bush 110324 Feb 21 11:27 cylstif.BL4
-rw-r--r--   1 bush bush    481 Feb 21 11:27 cylstif.BOS
-rw-r--r--   1 bush bush 182500 Feb 21 11:48 cylstif.CBL
-rw-r--r--   1 bush bush   3126 Feb 21 11:48 cylstif.DEC
-rw-r--r--   1 bush bush     30 Feb 21 11:18 cylstif.NAM
-rw-r--r--   1 bush bush  12112 Feb 21 11:18 cylstif.OPB
-rw-r--r--   1 bush bush   7934 Feb 21 11:48 cylstif.OPD
```

```
-rw-r--r--   1 bush bush      0 Feb 21 11:49 cylstif.OPM
-rw-r--r--   1 bush bush   4547 Feb 21 12:44 cylstif.OPT
-rw-r--r--   1 bush bush  33792 Feb 21 11:27 cylstif.RN1
-rw-r--r--   1 bush bush  36864 Feb 21 11:27 cylstif.RN2
-rw-r--r--   1 bush bush  33792 Feb 21 11:27 cylstif.RN3
-rw-r--r--   1 bush bush  33792 Feb 21 11:27 cylstif.RN4
```

The user-provided input data from the "MAINSETUP" interactive session are saved in the file, cylstif.OPT. A list of that file follows:

```
-------------------------------------------------------------
      n         $ Do you want a tutorial session and tutorial output?
  -25000.00     $ Resultant (e.g. lb/in) normal to the plane of screen, Nx( 1)
  -50000.00     $ Resultant (e.g. lb/in) in the plane of the screen,    Ny( 1)
   0.000000     $ 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?
   1.000000     $ Factor of safety for general instability, FSGEN( 1)
   1.000000     $ Factor of safety for panel (between rings) instability, FSPAN( 1)
   1.000000     $ 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)
      n         $ Do you want "flat skin" discretized module for local buckling?
      y         $ Do you want to skip the KOITER local postbuckling analysis?
      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)
         0      $ Axial load applied along the (0=neutral plane), (1=panel skin)
  -500.0000     $ Uniform applied pressure [positive upward. See H(elp)], p( 1)
      y         $ Is the pressure part of Load Set A?
      y         $ Is the pressure hydrostatic (Type H for "HELP")?
         1      $ Choose in-plane immovable (IFREE=0) or movable (IFREE=1) b.c.( 1)
      Y         $ Are you feeling well today (type H)?
      n         $ Is there a maximum allowable deflection due to pressure?
   0.000000     $ Out-of-roundness, Wimpg1=(Max.diameter-Min.diam)/4, Wimpg1( 1)
  0.5000000     $ Initial buckling modal general imperfection amplitude, Wimpg2( 1)
   0.000000     $ Initial buckling modal inter-ring imperfection amplitude,Wpan( 1)
   0.000000     $ Initial local imperfection amplitude (must be positive), Wloc( 1)
      y         $ Do you want PANDA2 to change imperfection amplitudes (see H(elp))?( 1)
   300.0000     $ Axial halfwavelength of typical general buckling mode, AXLWAV( 1)
      y         $ Do you want PANDA2 to find the general imperfection shape?( 1)
   1.000000     $ Maximum allowable average axial strain (type H for HELP)( 1)
      n         $ Is there any thermal "loading" in this load set (Y/N)?
      y         $ Do you want a "complete" analysis (type H for "Help")?
      n         $ Want to provide another load set ?
      n         $ Do you want to impose minimum TOTAL thickness of any segment?
      n         $ Do you want to impose maximum TOTAL thickness of any segment?
      n         $ Do you want to impose minimum TOTAL thickness of any segment?
      n         $ Do you want to impose maximum TOTAL thickness of any segment?
      y         $ 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)
      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)
---------------- end of cylstif.OPT file (input for MAINSETUP) -----------------
```

This file or an edited version of it can be used for future executions of the PANDA2 processor called "MAINSETUP". However, note that if you change certain of the input values, there may occur different prompts following the prompt corresponding to that change, and that therefore, an edited version of the *.OPT file may not represent valid input for MAINSETUP. For example, if you change IQUICK from 0 to 1 the three prompts that follow the prompt for IQUICK no longer occur.

PART 1.6: Execute the PANDA2 processor called "SUPEROPT" in order to search for a "global" optimum design.

bush-> superopt

```
The purpose of SUPEROPT is to launch the batch run which performs
multiple executions of the panda2 processors in the order:
  autochange  setup  pandaopt  pandaopt  pandaopt . . . .
The processor autochange automatically changes the decision variables
as follows:
           y(i) = x(i)*(1. + dx(i))   (i = 1,2,3,...no. of dec. var)
in which x(i) is the old value of the ith decision variable, y(i)
is the new value, and dx(i) is a random number between -0.5 and +1.5
The purpose of the successive cycles of
  autochange  setup  pandaopt  pandaopt  pandaopt . . . .
is to try to find a global optimum design by redesigning in each
cycle from a different starting point. The user should use a
small maximum number of design iterations (such as 5) in the file
case.OPT, where case is the user-specified name of the case.

Enter case name: cylstif
Enter number of executions of pandaopt
for each execution of autochange (5 or 6 or 7 or 8 or 9 or 10):5
B (background), F (foreground), or Q (NQS - network queue system): b
H (high) or L (low) priority: l
Diagnostics will be mailed to you upon program termination.
[1] 9539 9541
bush-> ps
  PID TTY          TIME CMD
 8496 pts1     00:00:00 tcsh
 9539 pts1     00:00:00 tcsh
 9540 pts1     00:00:00 csh
 9541 pts1     00:00:00 mail
 9607 pts1     00:00:06 main.linux
 9608 pts1     00:00:00 ps
bush-> /usr/sbin/sendmail: No such file or directory
```

In this case the SUPEROPT run bombed. At the time of the bomb the cylstif.OPP file (abridged) was as follows:

```
-------------- abridged cylstif.OPP file ----------------------
   1         B(STR):stiffener spacing, b: STR seg=NA, layer=NA =
  3.0000E+01  3.3000E+01  3.5640E+01  3.7920E+01  3.9861E+01  4.1494E+01
```

```
  2       B2(STR):width of stringer base, b2 (must be > 0, see Help): STR seg=2 , lay =
 9.9990E+00  1.0999E+01  1.1879E+01  1.2639E+01  1.3286E+01  1.3830E+01

  3        H(STR):height of stiffener (type H for sketch), h: STR seg=3 , layer=NA =
 1.0000E+01  9.0000E+00  8.2800E+00  7.7501E+00  7.3533E+00  7.0521E+00

  4        W(STR):width of outstanding flange of stiffener, w: STR seg=4 , layer=NA =
 1.0000E+01  1.0000E+01  9.2000E+00  8.6112E+00  8.2114E+00  7.8751E+00

  5     T(1 )(SKN):thickness for layer index no.(1 ): SKN seg=1 , layer=1 =
 8.1573E-01  8.9730E-01  9.0890E-01  9.6707E-01  1.0000E+00  1.0000E+00

  6     T(2 )(STR):thickness for layer index no.(2 ): STR seg=3 , layer=1 =
 8.1573E-01  8.9730E-01  9.6909E-01  1.0000E+00  1.0000E+00  9.5904E-01

  7     T(3 )(STR):thickness for layer index no.(3 ): STR seg=4 , layer=1 =
 8.1573E-01  7.3416E-01  6.7542E-01  6.3220E-01  5.9983E-01  5.7526E-01

  8        B(RNG):stiffener spacing, b: RNG seg=NA, layer=NA =
 5.0000E+01  4.5000E+01  4.1400E+01  4.2049E+01  3.9896E+01  3.8262E+01

  9       B2(RNG):width of ring base, b2 (zero is allowed): RNG seg=2 , layer=NA =
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00

 10        H(RNG):height of stiffener (type H for sketch), h: RNG seg=3 , layer=NA =
 1.0000E+01  1.1000E+01  1.1880E+01  1.1120E+01  1.0550E+01  1.0982E+01

 11        W(RNG):width of outstanding flange of stiffener, w: RNG seg=4 , layer=NA =
 1.0000E+01  9.0000E+00  8.2800E+00  7.7501E+00  7.3533E+00  7.0877E+00

 12     T(4 )(RNG):thickness for layer index no.(4 ): RNG seg=3 , layer=1 =
 8.1573E-01  7.3416E-01  6.7542E-01  6.3220E-01  5.9983E-01  6.1926E-01

 13     T(5 )(RNG):thickness for layer index no.(5 ): RNG seg=4 , layer=1 =
 8.1573E-01  8.2849E-01  7.6221E-01  7.1343E-01  6.7690E-01  7.0463E-01

********** OBJECTIVE FOR   6 ITERATIONS *********

  1    WEIGHT OF THE ENTIRE PANEL =
 1.5889E+04  1.6113E+04  1.5595E+04  1.5209E+04  1.4999E+04  1.4895E+04

  1    Absolute values of maximum constraint gradients, GRDPLT =
 3.6548E+00  6.8547E+00  4.8373E+00  4.9903E+00  4.6780E+00  0.0000E+00

(lines skipped to save space)


       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 1.5889E+04   NOT FEASIBLE  (0; 7)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
  2 1.6113E+04   NOT FEASIBLE  (0; 7)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
  3 1.5595E+04  UNKNOWN FEASIB.(0; 6)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
  4 1.5209E+04  UNKNOWN FEASIB.(0; 6)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
  5 1.4999E+04  UNKNOWN FEASIB.(0; 7)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
  6 1.4895E+04  ALMOST FEASIBLE(0; 6)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0

IOBJAL,ITRPLT=    0    6; OBJMN0,OBJPLT(ITRPLT)=  1.4895E+04  1.4895E+04
====================================================================================
```

```
----------- end of abridged cylstif.OPP file -------------


************* NOTE ************ NOTE *************** NOTE ************
The SUPEROPT run failed after 6 iterations because the
spacing between the stringers became too large for a model
in which IQUICK = 0. Here is part of the cylstif.ERR file:

------------------- part of the cylstif.ERR file -------------------

 IQUICK = quick analysis indicator (0 or 1)=         0


 ****** MODEL CHANGE REQUIRED ******
 Discretized model of single panel module cannot be treated
 because the stringer spacing spans too large a circumferential
 angle of the cylindrical panel or shell.

     STRINGER SPACING =   4.1494E+01
     CYLINDER RADIUS  =   1.0000E+02

 Please do one or more of the following

    1. set IQUICK = 1 (no discrete model of module is used) or
    2. make stringer spacing less than (cylinder radius)/3, or
    3. increase the cylinder radius or make panel module flat.
    4. if this message occurs at the end of a SUPEROPT run
       that bombed (see the *.ERR file) use "CHANGE" to save
       the best design so far (look at the end of *.OPP), and
       execute SETUP, MAINSETUP, and SUPEROPT again.
    5. read Item 675 of ...panda2/doc/panda2.news.
    6. possibly introduce an inequality constraint in DECIDE
       that forces B(STR) < (cylinder radius)/3.
 ****** MODEL CHANGE REQUIRED ******
---------- end of part of the cylstif.ERR file ---------------


This type of bomb is described in Item No. 580 of the file,
...panda2/doc/panda2.news, dated September, 2004. The initial
part of that "news" item is as follows:

---------------- from the ...panda2/doc/panda2.news file ---------------
580. September, 2004
Occasionally a run bombs during a SUPEROPT execution. When this happens do the
following. (Please read this entire news item before proceeding.)

SUMMARY of what to do:

1. look at the *.OPP file.
2. Look at the *.OPM file, especially the end of it.
3. Look at the *.ERR file, especially the end of it..

etc., etc.
----------- end of small part of panda2.news  -------------------


-----------------------------------------------------------------------
```

PART 1.7: Reset the upper bound of the stringer spacing in the file, cylstif.DEC, and restart from scratch.

In this case we will follow the alternative no. 2 listed above:

2. make stringer spacing less than (cylinder radius)/3

We will do this by setting the upper bound of the stringer spacing to less than radius/3. (We reset that upper bound to 30 inches.) Then we will start over from the beginning of the case by first "cleaning up" the cylstif files (cleanpan) and then executing the PANDA2 processors, BEGIN, SETUP, DECIDE, MAINSETUP, SUPEROPT, as follows:

bush-> cleanpan

```
Enter the case name: cylstif
You now have the following case cylstif files in your directory:
cylstif.BEG  cylstif.DEC  cylstif.OPT
```

bush-> begin

```
Please enter PANDA2 case name: cylstif


 ****************   BEGIN   ******************

 Purpose of BEGIN is to permit you to provide a starting design
 in an interactive mode. You give starting dimensions, material
 properties, allowables. The interactive session is stored on a
 file called cylstif.BEG, in which cylstif is a name that you have
 chosen for the case.(cylstif must remain the same as you use all
 the PANDA2 processors.)  In future runs of the same or a
 slightly modified case, you will find it convenient to use the
 file cylstif.BEG as input.  Rather than answer all the questions
 interactively, you can use cylstif.BEG or an edited version of
 cylstif.BEG as input to BEGIN.  BEGIN also generates an output
 file called cylstif.OPB. cylstif.OPB lists a summary of the case,
 and if you choose the tutorial option, the questions, helps,
 and your answers for each input datum.

 *************************************************

 Are you correcting, adding to, or using an existing file?=y

 (The "BEGIN" interactive session rolls by fast. Not reproduced
  here in order to save space.)

 Next, give a command  CHANGE or CHOOSETEMP  or   SETUP   .
```

bush-> setup

```
Enter case name: cylstif

 (Output from "SETUP" rolls by fast. Not reproduced
  here in order to save space.)

Pandaread pre-processor complete.
Next give the command: DECIDE or MAINSETUP.
```

************************ NOTE ****************************
Next, we edit the file, cylstif.DEC, in order to reduce the upper bound of the stringer spacing from 50 inches to 30 inches.

The part of the cylstif.DEC file involved before the edit is as follows:

```
         1      $ Choose a decision variable (1,2,3,...)
        10      $ Lower bound of variable no.( 1)
        50      $ Upper bound of variable no.( 1)
```

and after the edit is as follows:

```
         1      $ Choose a decision variable (1,2,3,...)
        10      $ Lower bound of variable no.( 1)
        30      $ Upper bound of variable no.( 1)
********************** END NOTE ****************************
```

Then we run DECIDE:

bush-> decide

```
Please enter PANDA2 case name: cylstif


 *****************   DECIDE   *******************

 The purpose of DECIDE is to permit you to choose decision
 variables, linked variables, and escape variables for the
 optimization run or runs to follow. The results of the
 interactive session are saved in a file called cylstif.DEC, in
 which cylstif is your name for the case. You may find this file
 useful for future runs of DECIDE in which you want to avoid
 answering many questions interactively. DECIDE also generates
 a file called cylstif.OPD.  cylstif.OPD contains a summary of
 optimization parameters. If you choose the tutorial option,
 cylstif.OPD contains a complete list of the interactive session,
 including prompting questions, all "help" paragraphs, your
 responses to the prompting questions, and evolving lists
 of optimization parameters as they are chosen by you.

 ****************************************************

 Are you correcting, adding to, or using an existing file?=y

 (The "DECIDE" interactive session rolls by fast. Not
  reproduced here in order to save space.)

 Next, give either command  CHOOSETEMP or MAINSETUP   .
```

bush-> mainsetup

```
Please enter PANDA2 case name: cylstif


  *****************   MAINSETUP   ****************
 The purpose of this processor is to permit you to choose loads
 and initial imperfections, Nx, Ny, Nxy, Mx, My, Nxo, Nyo, p,
 T(iseg), Wimp(global), Wimp(local),  (up to 5 sets of them);
 safety factors for general instability, panel instability,
 local instability (panel skin), local instability (stiffener
 parts), and stress; and strategy parameters for subsequent
 batch execution of an optimization analysis (analysis type 1);
 or an analysis of a fixed design at fixed load levels
 (analysis type 2); or an analysis of a fixed design for a
 single load set for monotonically increasing load levels
 (test simulation: analysis type 3).

 Results of the interactive session in MAINSETUP are saved on a
 file called cylstif.OPT, which will appear at the beginning of
```

```
 the cylstif.OPM file when the mainprocessor batch run launched
 by your command PANDAOPT has been completed.

 NOTE: JUST HIT "RETURN" FOR DEFAULT VALUE OF INPUT DATUM. IF
   PANDA2 REQUIRES AN INPUT, IT WILL SAY "PLEASE SAY SOMETHING"
  ***************************************************


 Are you correcting, adding to, or using an existing file?=y

 (The "MAINSETUP" interactive session rolls by fast. Not
  reproduced here in order to save space.)
```

Next, execute SUPEROPT again. This time it should not bomb because the stringer spacing cannot exceed 30 inches, which is less than a third of the radius of the cylindrical shell.

PART 1.8: Execute the PANDA2 processor called "SUPEROPT" in order to search for a "global" optimum design.

bush-> superopt

```
The purpose of SUPEROPT is to launch the batch run which performs
multiple executions of the panda2 processors in the order:
  autochange  setup  pandaopt  pandaopt  pandaopt . . . .
The processor autochange automatically changes the decision variables
as follows:
           y(i) = x(i)*(1. + dx(i))   (i = 1,2,3,...no. of dec. var)
in which x(i) is the old value of the ith decision variable, y(i)
is the new value, and dx(i) is a random number between -0.5 and +1.5
The purpose of the successive cycles of
  autochange  setup  pandaopt  pandaopt  pandaopt . . . .
is to try to find a global optimum design by redesigning in each
cycle from a different starting point. The user should use a
small maximum number of design iterations (such as 5) in the file
case.OPT, where case is the user-specified name of the case.

Enter case name: cylstif
Enter number of executions of pandaopt
for each execution of autochange (5 or 6 or 7 or 8 or 9 or 10):5
B (background), F (foreground), or Q (NQS - network queue system): b
H (high) or L (low) priority: l
Diagnostics will be mailed to you upon program termination.

bush-> /usr/sbin/sendmail: No such file or directory
```

The SUPEROPT execution requires only about 12 minutes for about 470 design iterations. The tail end of the cylstif.OPP file, which is output from SUPEROPT, has the following (abridged) information:

```
-------------- near the end of the cylstif.OPP file -----------------

        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 1.2211E+04      FEASIBLE   (0; 9)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
  2 1.2134E+04   NOT FEASIBLE  (0;11)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
  3 1.2478E+04      FEASIBLE   (0; 3)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
  4 1.2200E+04   NOT FEASIBLE  (0; 9)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
  5 1.2420E+04      FEASIBLE   (0; 3)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
  6 1.2243E+04  MOSTLY UNFEASIB(0; 9)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
------------------------------------------------------PANDAOPT
  7 1.2243E+04  MOSTLY UNFEASIB(0; 9)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
  8 1.2679E+04      FEASIBLE   (0; 0)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
  9 1.2325E+04  MOSTLY UNFEASIB(0; 9)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 10 1.2605E+04      FEASIBLE   (0; 2)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 11 1.2379E+04      FEASIBLE   (0; 3)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 12 1.2203E+04   NOT FEASIBLE  (0; 9)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
------------------------------------------------------PANDAOPT
 13 1.2203E+04   NOT FEASIBLE  (0; 9)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 14 1.2638E+04      FEASIBLE   (0; 0)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 15 1.2285E+04  MOSTLY UNFEASIB(0; 9)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 16 1.2564E+04      FEASIBLE   (0; 3)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 17 1.2338E+04  MOSTLY UNFEASIB(0; 9)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 18 1.2517E+04      FEASIBLE   (0; 3)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
------------------------------------------------------PANDAOPT
 19 1.2517E+04      FEASIBLE   (0; 3)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 20 1.2132E+04   NOT FEASIBLE  (0;11)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 21 1.2477E+04      FEASIBLE   (0; 3)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 22 1.2198E+04   NOT FEASIBLE  (0; 9)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 23 1.2419E+04      FEASIBLE   (0; 3)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 24 1.2241E+04  MOSTLY UNFEASIB(0; 9)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
------------------------------------------------------PANDAOPT
 25 1.2241E+04  MOSTLY UNFEASIB(0; 9)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 26 1.2679E+04      FEASIBLE   (0; 0)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 27 1.2324E+04      FEASIBLE   (0; 6)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 28 1.2102E+04   NOT FEASIBLE  (0;11)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 29 1.2321E+04      FEASIBLE   (0; 3)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 30 1.2145E+04   NOT FEASIBLE  (0;10)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
----------------------------------------------------AUTOCHANGE
------------------------------------------------------PANDAOPT
 31 3.1201E+04      FEASIBLE   (0; 0)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 32 2.4518E+04      FEASIBLE   (0; 0)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 33 2.0371E+04  UNKNOWN FEASIB.(0; 0)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 34 1.7979E+04  UNKNOWN FEASIB.(0; 1)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 35 1.6643E+04  UNKNOWN FEASIB.(0; 2)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 36 1.5894E+04  ALMOST FEASIBLE(0; 3)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
------------------------------------------------------PANDAOPT
 37 1.5894E+04  ALMOST FEASIBLE(0; 3)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 38 1.4687E+04  MILDLY UNFEASIB(0; 4)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 39 1.4141E+04      FEASIBLE   (0; 0)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 40 1.2907E+04   NOT FEASIBLE  (0; 9)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 41 1.4159E+04      FEASIBLE   (0; 3)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
 42 1.3544E+04      FEASIBLE   (0; 1)  (0; 0)  (0; 0)  (0; 0)  (0; 0)   0 0 0 0 0 0 N 0 0 0 0 0 0
------------------------------------------------------PANDAOPT

(many lines skipped to save space)


 VALUES OF DESIGN VARIABLES CORRESPONDING TO BEST FEASIBLE DESIGN
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE            DEFINITION
 1         0     0    1.037E+01       B(STR):stiffener spacing, b: STR seg=NA, layer=NA
 2   STR   2     0    3.455E+00      B2(STR):width of stringer base, b2 (must be > 0, see Help):
STR seg=2 , lay
 3   STR   3     0    8.014E+00       H(STR):height of stiffener (type H for sketch), h: STR seg=3
, layer=NA
 4   STR   4     0    1.829E+00       W(STR):width of outstanding flange of stiffener, w: STR seg=4
, layer=NA
 5   SKN   1     1    7.971E-01    T(1 )(SKN):thickness for layer index no.(1 ): SKN seg=1 , layer=1
 6   STR   3     1    2.546E-01    T(2 )(STR):thickness for layer index no.(2 ): STR seg=3 , layer=1
 7   STR   4     1    1.254E-01    T(3 )(STR):thickness for layer index no.(3 ): STR seg=4 , layer=1
```

```
  8         0     0   3.705E+01        B(RNG):stiffener spacing, b: RNG seg=NA, layer=NA
  9   RNG   2     0   0.000E+00       B2(RNG):width of ring base, b2 (zero is allowed): RNG seg=2 ,
layer=NA
 10   RNG   3     0   1.109E+01        H(RNG):height of stiffener (type H for sketch), h: RNG seg=3
, layer=NA
 11   RNG   4     0   4.287E+00        W(RNG):width of outstanding flange of stiffener, w: RNG seg=4
, layer=NA
 12   RNG   3     1   6.531E-01    T(4 )(RNG):thickness for layer index no.(4 ): RNG seg=3 , layer=1
 13   RNG   4     1   7.269E-01    T(5 )(RNG):thickness for layer index no.(5 ): RNG seg=4 , layer=1

 ***************************************************
 ******************* DESIGN OBJECTIVE ******************
 *************                             ***********

  CORRESPONDING VALUE OF THE OBJECTIVE FUNCTION:
 VAR. STR/ SEG. LAYER   CURRENT
 NO.  RNG  NO.   NO.     VALUE           DEFINITION
            0     0   1.221E+04   WEIGHT OF THE ENTIRE PANEL

 *************                          ************
 ******************* DESIGN OBJECTIVE ******************
 *****************************************************
--------- end of the abridged list of the cylstif.OPP file ---------------


------------------------------------------------------------------------
```

PART 1.9: Execute the PANDA2 processor called "CHOOSEPLOT" in order to choose what to plot.

Next, execute CHOOSEPLOT:

bush-> chooseplot

```
Please enter PANDA2 case name: cylstif


 ***************** CHOOSEPLOT  *******************
 The purpose of CHOOSEPLOT is to permit you to choose:

    1. Which design variables (decision variable candidates)
       are to be plotted v. design iterations (ITYPE=1);
    2. Which behaviors to plot v. load steps (ITYPE=3);
    3. Which sensitivity plots to obtain (ITYPE=4);
    4. At which locations to plot extreme fiber strains
       (ITYPE=3);
    5. Which design margins are to be plotted v. design
       iterations (ITYPE=1) or load steps (ITYPE=3) or
       design variable (ITYPE=4) or load combo (ITYPE=5).
    6. For which load steps to plot the deformed panel
       module (ITYPE=3).
    7. Whether or not to plot the layup configuration of the
       skin-stringer panel module (ITYPE=3)
    8. Whether or not to obtain a "3-D" plot of the locally
       post-buckled panel module (ITYPE=3)

 The results of the interactive session are saved in a file
 called cylstif.CPL, in which cylstif is your name for the case.
 You may find this file useful for future runs of CHOOSEPLOT
 in which you want to avoid answering many questions
 interactively. CHOOSEPLOT also generates the six files:
 cylstif.OPL, cylstif.PL3, cylstif.PL4, cylstif.PL5, cylstif.PL6,
 cylstif.PL7,cylstif.PL8,cylstif.PL9,cylstif.PL10, which are described
 briefly at the end of this run.
 If you choose the tutorial option, cylstif.OPL contains a
```

```
 complete list of the interactive session, including prompting
 questions, all "help" paragraphs, your responses to the
 prompting questions, and evolving lists of which parameters
 are to be plotted as they are chosen by you.
 ****************************************************

 Are you correcting, adding to, or using an existing file?=n
 n
 Do you want a tutorial session and tutorial output?=n
 n
 Any design variables to be plotted v. iterations (Y or N)?=n
 n
 Any design margins to be plotted (Y or N)?=n
 n
 Do you want a plot of the objective v. iterations (Y/N)?=y
 y
 Do you want to get more plots before your next "SUPEROPT"?=n


 DESCRIPTION OF FILES GENERATED BY THIS CASE:

 cylstif.CPL = Summary of interactive session you have just
          completed. This file can be edited and used for
          future runs of CHOOSEPLOT.
 cylstif.CBL = Contains the cylstif data base.
 cylstif.OPL = Output from CHOOSEPLOT. Please list this file and
          inspect it and the cylstif.CPL file carefully before
          proceeding.

 cylstif.PL3 = File for margin plots via DIPLOT
 cylstif.PL4 = File for design variable plots (ITYPE=1) or
            behavior v. load plots (ITYPE=3) or in-plane load
            interaction curves (ITYPE=5) via DIPLOT
 cylstif.PL5 = File for objective plot (ITYPE=1) or undeformed
            and deformed panel module (ITYPE=3) or in-plane
            load combinations (ITYPE=5) via DIPLOT
 cylstif.PL6 = File for plot of layup of skin-stringer module
             (ITYPE=3).

 cylstif.PL7 = File for "3-D" plot of locally post-buckled panel
            module. (ITYPE=3).
 cylstif.PL8 = File for plot of AXIAL or +45deg. extreme fiber
             strains v. a selected load component (ITYPE=3).
 cylstif.PL9 = File for plot of HOOP or -45deg. extreme fiber
             strains v. a selected load component (ITYPE=3).
 cylstif.PL10= File for plot of SHEAR strains at 0deg. or 45deg.
             v. a selected load component (ITYPE=3).

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

 NEXT, INSPECT THE FILE cylstif.OPL AND THEN IF ALL IS OKAY,
 GIVE THE COMMAND:  DIPLOT   .
```

The interactive "CHOOSEPLOT" session produces the following file:

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

This short file contains valid input for the next execution of CHOOSEPLOT.

PART 1.10: Execute the PANDA2 processor called "DIPLOT" in order to generate Postscript files for plotting.

bush-> diplot

```
Enter the PANDA2 case name: cylstif
Print the plot file on the printer called: <lp> (y or n)? n
The PostScript files, cylstif.3.ps through cylstif.10.ps, contain the
graphics for your plot.  They can be printed on any PostScript
printer or viewed on the console with a PostScript previewing
software program.
```

The files now existing in the working directory are as follows:

```
-rw-r--r--   1 bush bush      76 Feb 21 18:29 cylstif.010
-rw-r--r--   1 bush bush   30290 Feb 21 18:30 cylstif.5.ps
-rw-r--r--   1 bush bush    2046 Feb 21 17:56 cylstif.AL2
-rw-r--r--   1 bush bush    2058 Feb 21 17:46 cylstif.AL3
-rw-r--r--   1 bush bush    2058 Feb 21 17:56 cylstif.ALL
-rw-r--r--   1 bush bush    5604 Feb 21 11:18 cylstif.BEG
-rw-r--r--   1 bush bush  110324 Feb 21 17:57 cylstif.BL1
-rw-r--r--   1 bush bush  110324 Feb 21 17:57 cylstif.BL2
-rw-r--r--   1 bush bush  110324 Feb 21 17:56 cylstif.BL3
-rw-r--r--   1 bush bush  110324 Feb 21 17:46 cylstif.BL4
-rw-r--r--   1 bush bush     481 Feb 21 17:56 cylstif.BOS
-rw-r--r--   1 bush bush  182500 Feb 21 18:29 cylstif.CBL
-rw-r--r--   1 bush bush     360 Feb 21 18:29 cylstif.CPL
-rw-r--r--   1 bush bush    3126 Feb 21 17:45 cylstif.DEC
-rw-r--r--   1 bush bush      30 Feb 21 17:45 cylstif.NAM
-rw-r--r--   1 bush bush    2678 Feb 21 17:56 cylstif.OPA
-rw-r--r--   1 bush bush   12112 Feb 21 17:45 cylstif.OPB
-rw-r--r--   1 bush bush    7934 Feb 21 17:46 cylstif.OPD
-rw-r--r--   1 bush bush   12599 Feb 21 18:29 cylstif.OPL
-rw-r--r--   1 bush bush 2989030 Feb 21 17:57 cylstif.OPM
-rw-r--r--   1 bush bush  497082 Feb 21 17:57 cylstif.OPP
-rw-r--r--   1 bush bush    4547 Feb 21 12:44 cylstif.OPT
-rw-r--r--   1 bush bush   56760 Feb 21 17:57 cylstif.P11
-rw-r--r--   1 bush bush   51084 Feb 21 17:57 cylstif.P21
-rw-r--r--   1 bush bush   25752 Feb 21 17:57 cylstif.PL1
-rw-r--r--   1 bush bush       0 Feb 21 18:26 cylstif.PL10
-rw-r--r--   1 bush bush   34056 Feb 21 17:57 cylstif.PL2
-rw-r--r--   1 bush bush       0 Feb 21 18:26 cylstif.PL3
-rw-r--r--   1 bush bush       0 Feb 21 18:26 cylstif.PL4
-rw-r--r--   1 bush bush   12074 Feb 21 18:29 cylstif.PL5
-rw-r--r--   1 bush bush       0 Feb 21 18:26 cylstif.PL6
-rw-r--r--   1 bush bush       0 Feb 21 18:26 cylstif.PL7
-rw-r--r--   1 bush bush       0 Feb 21 18:26 cylstif.PL8
-rw-r--r--   1 bush bush       0 Feb 21 18:26 cylstif.PL9
-rw-r--r--   1 bush bush   34056 Feb 21 17:57 cylstif.PLD
-rw-r--r--   1 bush bush  854528 Feb 21 17:57 cylstif.RN1
-rw-r--r--   1 bush bush  626688 Feb 21 17:56 cylstif.RN2
-rw-r--r--   1 bush bush  574464 Feb 21 17:56 cylstif.RN3
-rw-r--r--   1 bush bush   33792 Feb 21 17:46 cylstif.RN4
-rw-r--r--   1 bush bush   79633 Feb 21 17:57 cylstif.TIT
```

In this particular case there is only a single Postscript file generated by DIPLOT:

```
-rw-r--r--   1 bush bush   30290 Feb 21 18:30 cylstif.5.ps
```

This plot contains the objective versus design iterations
during the SUPEROPT execution. In order to see the plot on
your screen, type the following command:

gv cylstif.5.ps

("gv" means "ghost view", a utility for reading Postscript
files and producing the plot image on your screen.)

A screen "snapshot" of the plot is taken and stored in the file:

1.cylstif.superopt1.objective.png   (All the *.png files are appended at the bottom of this file.)

PART 1.11: Execute the PANDA2 processors called "SUPEROPT" and "DIPLOT"again in order to 1. search for a "global" optimum design that may weigh less than the optimum design determined so far, and 2. to plot the objective versus design iterations.

Next, run SUPEROPT again. Maybe there is a FEASIBLE or
ALMOST FEASIBLE design with a smaller weight than that
found in PART 1.8 and listed at the end of PART 1.8: 1.221E+04 lb.

bush-> superopt

```
The purpose of SUPEROPT is to launch the batch run which performs
multiple executions of the panda2 processors in the order:
  autochange  setup  pandaopt  pandaopt  pandaopt . . . .
The processor autochange automatically changes the decision variables
as follows:
           y(i) = x(i)*(1. + dx(i))   (i = 1,2,3,...no. of dec. var)
in which x(i) is the old value of the ith decision variable, y(i)
is the new value, and dx(i) is a random number between -0.5 and +1.5
The purpose of the successive cycles of
  autochange  setup  pandaopt  pandaopt  pandaopt . . . .
is to try to find a global optimum design by redesigning in each
cycle from a different starting point. The user should use a
small maximum number of design iterations (such as 5) in the file
case.OPT, where case is the user-specified name of the case.

Enter case name: cylstif
Enter number of executions of pandaopt
for each execution of autochange (5 or 6 or 7 or 8 or 9 or 10):5
B (background), F (foreground), or Q (NQS - network queue system): b
H (high) or L (low) priority: l
Diagnostics will be mailed to you upon program termination.

bush-> /usr/sbin/sendmail: No such file or directory
```

The abridged cylstif.OPP file includes the following
optimized design after completion of the second execution of
SUPEROPT:

```
------------- from the cylstif.OPP file ---------------------
  VALUES OF DESIGN VARIABLES CORRESPONDING TO BEST FEASIBLE DESIGN
```

```
 VAR. STR/ SEG. LAYER   CURRENT
 NO.  RNG  NO.   NO.     VALUE            DEFINITION
  1         0     0   1.011E+01       B(STR):stiffener spacing, b: STR seg=NA, layer=NA
  2   STR   2     0   3.370E+00      B2(STR):width of stringer base, b2 (must be > 0, see
Help): STR seg=2 , lay
  3   STR   3     0   7.817E+00       H(STR):height of stiffener (type H for sketch), h:
STR seg=3 , layer=NA
  4   STR   4     0   2.534E+00       W(STR):width of outstanding flange of stiffener, w:
STR seg=4 , layer=NA
  5   SKN   1     1   7.690E-01   T(1 )(SKN):thickness for layer index no.(1 ): SKN seg=1
, layer=1
  6   STR   3     1   2.038E-01   T(2 )(STR):thickness for layer index no.(2 ): STR seg=3
, layer=1
  7   STR   4     1   8.450E-02   T(3 )(STR):thickness for layer index no.(3 ): STR seg=4
, layer=1
  8         0     0   3.185E+01       B(RNG):stiffener spacing, b: RNG seg=NA, layer=NA
  9   RNG   2     0   0.000E+00      B2(RNG):width of ring base, b2 (zero is allowed):
RNG seg=2 , layer=NA
 10   RNG   3     0   9.783E+00       H(RNG):height of stiffener (type H for sketch), h:
RNG seg=3 , layer=NA
 11   RNG   4     0   4.304E+00       W(RNG):width of outstanding flange of stiffener, w:
RNG seg=4 , layer=NA
 12   RNG   3     1   5.673E-01   T(4 )(RNG):thickness for layer index no.(4 ): RNG seg=3
, layer=1
 13   RNG   4     1   9.452E-01   T(5 )(RNG):thickness for layer index no.(5 ): RNG seg=4
, layer=1

 ***************************************************
 ******************** DESIGN OBJECTIVE *******************
 *************                             ***********

  CORRESPONDING VALUE OF THE OBJECTIVE FUNCTION:
 VAR. STR/ SEG. LAYER   CURRENT
 NO.  RNG  NO.   NO.     VALUE            DEFINITION
            0     0   1.178E+04   WEIGHT OF THE ENTIRE PANEL

 *************                          ************
 ******************** DESIGN OBJECTIVE *******************
 *****************************************************
--------------- end of abridged cylstif.OPP file --------------
```

It turns out there IS a slightly smaller optimized weight,
1.178E+04 lb versus the 1.221E+04 lb determined in PART 1.8.

Next, we want to obtain a plot of the objective versus
the design iterations during the second execution of SUPEROPT:

bush-> chooseplot

Please enter PANDA2 case name: cylstif

(We use the same input file for CHOOSEPLOT
that we used after the first execution of
SUPREOPT. The interactive CHOOSEPLOT execution
rolls by on the screen very fast.)

bush-> diplot

```
Enter the PANDA2 case name: cylstif
Print the plot file on the printer called: <lp> (y or n)? n
The PostScript files, cylstif.3.ps through cylstif.10.ps, contain the
graphics for your plot.  They can be printed on any PostScript
printer or viewed on the console with a PostScript previewing
```

software program.

The Postscript file for plotting is:
```
-rw-r--r--   1 bush bush   30646 Feb 22 07:50 cylstif.5.ps
```

This plot contains the objective versus design iterations during the SUPEROPT execution. In order to see the plot on your screen, type the following command:

gv cylstif.5.ps

("gv" means "ghost view", a utility for reading Postscript files and producing the plot image on your screen.)

A screen "snapshot" of the plot is taken and stored in the

2.cylstif.superopt2.objective.png (All the *.png files are appended at the end of this file.)

PART 1.12: Execute the PANDA2 processor called "MAINSETUP" again in order to set up a run for a fixed design (ITYPE=2): the optimum design with the weight, 1.178E+04 lb.

Next, we wish to obtain results for the optimized design. We edit the cylstif.OPT file (input for MAINSETUP) by changing ITYPE from 1 (optimization) to 2 (analysis of a fixed design):

```
  2   $ Choose type of analysis (ITYPE = 1 or 2 or 3 or 4 or 5)
```

We also change the output index, NPRINT, from 0 to -1, as follows:

```
 -1   $ NPRINT= output index (-1=min. 0=good, 1=ok, 2=more, 3=too much)
```

This is done only for the purpose of this presentation. Ordinarily, you would use NPRINT = 0 or NPRINT = 2

Next, we execute MAINSETUP with the new values for ITYPE (ITYPE=2) and NPRINT (NPRINT = -1):

bush-> mainsetup

```
Please enter PANDA2 case name: cylstif

  *****************   MAINSETUP   ****************
 The purpose of this processor is to permit you to choose loads
 and initial imperfections, Nx, Ny, Nxy, Mx, My, Nxo, Nyo, p,
 T(iseg), Wimp(global), Wimp(local),  (up to 5 sets of them);
 safety factors for general instability, panel instability,
 local instability (panel skin), local instability (stiffener
 parts), and stress; and strategy parameters for subsequent
 batch execution of an optimization analysis (analysis type 1);
 or an analysis of a fixed design at fixed load levels
 (analysis type 2); or an analysis of a fixed design for a
 single load set for monotonically increasing load levels
 (test simulation: analysis type 3).
```

Results of the interactive session in MAINSETUP are saved on a
file called cylstif.OPT, which will appear at the beginning of
the cylstif.OPM file when the mainprocessor batch run launched
by your command PANDAOPT has been completed.

```
 NOTE: JUST HIT "RETURN" FOR DEFAULT VALUE OF INPUT DATUM. IF
   PANDA2 REQUIRES AN INPUT, IT WILL SAY "PLEASE SAY SOMETHING"
  ***************************************************

 Are you correcting, adding to, or using an existing file?=y
```

(The interactive "MAINSETUP" session rolls by on the screen
very fast. We next give the command, PANDAOPT, and thereby
obtain results for the fixed, optimized design.)

PART 1.13: Execute the PANDA2 processor called "PANDAOPT" for the analysis of the fixed, optimized design

bush-> pandaopt

The purpose of PANDAOPT is to launch the batch run which performs
optimization or buckling according to the strategy parameters
established the last time you did a MAINSETUP. Output from PANDAOPT
is stored in a file called casename.OPM, in which casename is
the name of the case. You will want to examine casename.OPM as soon
as PANDAOPT is finished.

```
Enter case name: cylstif
B (background), F (foreground), or Q (NQS - network queue system): f

Running PANDA2: pandaopt, case: cylstif

Executing main
Normal termination: main
still processing... Please wait.
Executing store
Normal termination: store
still processing... Please wait.
cylstif mainprocessor run completed successfully.
Menu: PANDAOPT, CHOOSEPLOT, MAINSETUP, CHANGE
Please examine the files: cylstif.OPM, cylstif.OPP, and cylstif.OPI
If ITYPE=1, print the file called cylstif.OPP
If ITYPE=3 or 4, print the file called cylstif.OPI
Run PANDAOPT several times for optimization.
```

PART 1.14: Inspect the output from PANDAOPT, the cylstif.OPM file

Next, inspect the file, cylstif.OPM, which is the list
of output from PANDAOPT. A somewhat abridged version of
the file, cylstif.OPM, follows:

------ abridged version of the file, cylstif.OPM ----------

(lines skipped to save space)

```
 ************ AUGUST, 2010 VERSION OF PANDA2   ************
 ******** BEGINNING OF THE  cylstif.OPM  FILE *********
```

```
  (lines skipped to save space)

 MARGINS FOR CURRENT DESIGN: LOAD CASE NO. 1, SUBCASE NO. 1
 MAR. MARGIN
 NO.  VALUE                DEFINITION
 1   3.18E-03 Local buckling from discrete model-1.,M=1   axial halfwaves;FS=1.1
 2   3.18E-03 Bending-torsion buckling; M=1  ;FS=1.1
 3   1.99E-01 eff.stress:matl=1,SKN,Dseg=2,node=6,layer=1,z=0.3845; MID.;FS=1.
 4   1.97E-02 (m=1   lateral-torsional buckling load factor)/(FS)-1;FS=1.1
 5   2.96E-02 Inter-ring bucklng, discrete model, n=32  circ.halfwaves;FS=1.1
 6   8.83E-01 Lo-n Ring sidesway, discrete model, n=1   circ.halfwaves;FS=1.1
 7   1.21E-02 eff.stress:matl=1,RNG,Iseg=4,allnode,layer=1,z=-0.4726;-MID.;FS=1.
 8   5.86E-01 buckling margin stringer Iseg.3 . Local halfwaves=4  .MID.;FS=1.
 9   1.82E-02 buckling margin stringer Iseg.4 . Local halfwaves=4  .MID.;FS=1.
10   1.23E-01 buckling stringer Isegs.3+4 together.M=4  ;C=0.     ;MID.;FS=1.4
11   6.96E+00 buckling stringer Iseg 4 as beam on foundation. M=369;MID.;FS=1.2
12   1.31E+00 buckling margin   ring   Iseg.3 . Local halfwaves=32 .MID.;FS=1.
13   7.03E+00 buckling   ring   Iseg 4 as beam on foundation. M=67 ;MID.;FS=1.2
14   7.86E-01 buck.(SAND);simp-support general buck;M=1;N=3;slope=0.;FS=1.1
15   5.89E-01 buck.(SAND);rolling with smear string;M=1;N=20;slope=0.;FS=1.1
16   1.71E+01 buck.(SAND);rolling with smear rings; M=93;N=1;slope=0.;FS=1.1
17   1.61E-01 buck.(SAND);rolling only of stringers;M=8;N=0;slope=0.;FS=1.4
18   8.73E-01 buck.(SAND);hiwave roll. of stringers;M=54;N=0;slope=0.;FS=1.2
19   1.91E-02 buck.(SAND);rolling only of   rings;  M=0;N=4;slope=0.;FS=1.4
20   1.69E-01 buck.(SAND);rolling only axisym.rings;M=0;N=0;slope=0.;FS=1.4
21   3.89E-01 buck.(SAND); STRINGERS:  web buckling;M=4;N=1;slope=0.01;FS=1.
22   1.05E+00 buck.(SAND);   RINGS:    web buckling;M=26;N=1;slope=0.04;FS=1.
23   6.93E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.

  (lines skipped to save space)

 MARGINS FOR CURRENT DESIGN: LOAD CASE NO. 1, SUBCASE NO. 2
 MAR. MARGIN
 NO.  VALUE                DEFINITION
 1   3.18E-03 Local buckling from discrete model-1.,M=1   axial halfwaves;FS=1.1
 2   1.03E-01 Bending-torsion buckling; M=1  ;FS=1.
 3   2.66E-01 eff.stress:matl=1,STR,Dseg=5,node=11,layer=1,z=-0.3845; RNGS;FS=1.
 4   1.97E-02 (m=1   lateral-torsional buckling load factor)/(FS)-1;FS=1.1
 5   1.09E-01 Inter-ring bucklng, discrete model, n=32  circ.halfwaves;FS=1.1
 6   3.02E-01 Lo-n Ring sidesway, discrete model, n=5   circ.halfwaves;FS=1.1
 7   1.21E-02 eff.stress:matl=1,RNG,Iseg=4,allnode,layer=1,z=-0.4726;-RNGS;FS=1.
 8   5.86E-01 buckling margin stringer Iseg.3 . Local halfwaves=4  .RNGS;FS=1.
 9   1.82E-02 buckling margin stringer Iseg.4 . Local halfwaves=4  .RNGS;FS=1.
10   1.23E-01 buckling stringer Isegs.3+4 together.M=4  ;C=0.     ;RNGS;FS=1.4
11   6.96E+00 buckling stringer Iseg 4 as beam on foundation. M=369;RNGS;FS=1.2
12   1.31E+00 buckling margin   ring   Iseg.3 . Local halfwaves=32 .RNGS;FS=1.
13   7.03E+00 buckling   ring   Iseg 4 as beam on foundation. M=67 ;RNGS;FS=1.2
14   1.71E+01 buck.(SAND);rolling with smear rings; M=93;N=1;slope=0.;FS=1.1
15   1.61E-01 buck.(SAND);rolling only of stringers;M=8;N=0;slope=0.;FS=1.4
16   8.73E-01 buck.(SAND);hiwave roll. of stringers;M=54;N=0;slope=0.;FS=1.2
17   1.69E-01 buck.(SAND);rolling only axisym.rings;M=0;N=0;slope=0.;FS=1.4
18   3.89E-01 buck.(SAND); STRINGERS:  web buckling;M=4;N=1;slope=0.01;FS=1.
19   1.05E+00 buck.(SAND);   RINGS:    web buckling;M=26;N=1;slope=0.04;FS=1.
20   6.93E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
 ***********  ALL 1 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  1.00E+01 1.0110E+01  3.00E+01
B(STR):stiffener spacing, b: STR seg=NA, layer=NA
   2   N     N     Y      1    3.33E-01  0.00E+00 3.3698E+00  0.00E+00       B2(STR):width
of stringer base, b2 (must be > 0, see
```

```
   3   Y     N     N      0    0.00E+00  5.00E-01 7.8167E+00  2.00E+01
H(STR):height of stiffener (type H for sketch), h:
   4   Y     N     N      0    0.00E+00  5.00E-01 2.5340E+00  1.00E+01        W(STR):width
of outstanding flange of stiffener, w:
   5   Y     Y     N      0    0.00E+00  5.00E-02 7.6896E-01  1.00E+00    T(1
)(SKN):thickness for layer index no.(1 ): SKN seg=1
   6   Y     Y     N      0    0.00E+00  1.00E-02 2.0380E-01  1.00E+00    T(2
)(STR):thickness for layer index no.(2 ): STR seg=3
   7   Y     Y     N      0    0.00E+00  1.00E-02 8.4496E-02  1.00E+00    T(3
)(STR):thickness for layer index no.(3 ): STR seg=4
   8   Y     N     N      0    0.00E+00  1.00E+01 3.1850E+01  1.00E+02
B(RNG):stiffener spacing, b: RNG seg=NA, layer=NA
   9   N     N     N      0    0.00E+00  0.00E+00 0.0000E+00  0.00E+00       B2(RNG):width
of ring base, b2 (zero is allowed): RN
  10   Y     N     N      0    0.00E+00  5.00E-01 9.7830E+00  2.00E+01
H(RNG):height of stiffener (type H for sketch), h:
  11   Y     N     N      0    0.00E+00  5.00E-01 4.3037E+00  1.00E+01        W(RNG):width
of outstanding flange of stiffener, w:
  12   Y     Y     N      0    0.00E+00  1.00E-02 5.6729E-01  1.00E+00    T(4
)(RNG):thickness for layer index no.(4 ): RNG seg=3
  13   Y     Y     N      0    0.00E+00  1.00E-02 9.4524E-01  1.00E+00    T(5
)(RNG):thickness for layer index no.(5 ): RNG seg=4


   CURRENT VALUE OF THE OBJECTIVE FUNCTION:
 VAR. STR/ SEG. LAYER   CURRENT
 NO.  RNG  NO.   NO.     VALUE            DEFINITION
           0     0   1.178E+04   WEIGHT OF THE ENTIRE PANEL

  TOTAL WEIGHT OF SKIN                            =   7.2473E+03
  TOTAL WEIGHT OF SUBSTIFFENERS                   =   0.0000E+00
  TOTAL WEIGHT OF STRINGERS                       =   1.6846E+03
  TOTAL WEIGHT OF RINGS                           =   2.8460E+03
  SPECIFIC WEIGHT (WEIGHT/AREA) OF STIFFENED PANEL=   1.2497E-01
 IN ORDER TO AVOID FALSE CONVERGENCE OF THE DESIGN, BE SURE TO
 RUN  PANDAOPT  MANY TIMES DURING AN OPTIMIZATION. INSPECT THE
 cylstif.OPP  FILE AFTER EACH OPTIMIZATION RUN. OR BETTER YET,
 RUN SUPEROPT.
 **** NOTE: It is almost always best to set the number of ****
 **** iterations per execution of "PANDAOPT" equal to 5   ****
 **** in response to the following prompt in "MAINSETUP": ****
 "How many design iterations permitted in this run (5 to 25)?"
 **** Hence, the *.OPT file should almost always have the ****
 **** following line in it:                               ****
 "5   $ How many design iterations in this run (5 to 25)?"
 ******************** END OF cylstif.OPM FILE ****************

----- end of the cylstif.OPM file (fixed, optimum design) ------

In the list above:

"MARGINS FOR CURRENT DESIGN: LOAD CASE NO. 1, SUBCASE NO. 1"

means conditions at midbay, in this case, midway between adjacent
rings (SUBCASE 1).

"MARGINS FOR CURRENT DESIGN: LOAD CASE NO. 1, SUBCASE NO. 2"

means conditions at a ring station (SUBCASE 2)


-----------------------------------------------------------------------
```

**PART 1.15: Execute the PANDA2 processor called "CHANGE"
in order to archive the optimized design**

Next, we wish to save the optimized design by executing the interactive session, "CHANGE", as follows:

bush-> change

```
Please enter PANDA2 case name: cylstif


 ******************   CHANGE   *******************

 You use CHANGE to change parameters without having to go back
 to BEGIN. The parameters you can change are segregated into
 three groups:

    1. parameters elegible to be decision variables
    2. parameters not elegible to be decision variables
    3. allowables (for example, max. strain).

 Your interactive input is saved on a file called cylstif.CHG, in
 which cylstif is the same name you used for BEGIN, SETUP, etc.
 A summary of the output from CHANGE is stored in cylstif.OPC.

 ************************************************************

 Are you correcting, adding to, or using an existing file?=n
 n
 Do you want a tutorial session and tutorial output?=n
 n

 This program permits you to change certain quantities without
 starting over from the beginning (without having to use BEGIN).

 Parameters that you can change are segregated into three sets:

    1. parameters that are "elegible" to be decision variables;
    2. parameters that are always considered to be fixed
       during design iterations: they are not elegible
       to be decision variables;
    3. parameters that are allowables, such as max. stress.

 You will next be asked if you want to change any parameters in
 set no. 1, and if so, which; then you will be asked the same
 questions relative to set no. 2; and finally the same questions
 relative to set no. 3.

 Do you want to change any values in Parameter Set No. 1?=y
 y
 PARAMETERS WHICH CAN BE CHANGED.   CHOOSE ONE OF THE FOLLOWING
 VAR. STR/ SEG. LAYER   CURRENT
 NO.  RNG  NO.   NO.     VALUE            DEFINITION
  1         0     0   1.011E+01       B(STR):stiffener spacing, b: STR seg=NA,
  2   STR   2     0   3.370E+00      B2(STR):width of stringer base, b2 (must
  3   STR   3     0   7.817E+00       H(STR):height of stiffener (type H for s
  4   STR   4     0   2.534E+00       W(STR):width of outstanding flange of st
  5   SKN   1     1   7.690E-01    T(1 )(SKN):thickness for layer index no.(1 )
  6   STR   3     1   2.038E-01    T(2 )(STR):thickness for layer index no.(2 )
  7   STR   4     1   8.450E-02    T(3 )(STR):thickness for layer index no.(3 )
  8         0     0   3.185E+01       B(RNG):stiffener spacing, b: RNG seg=NA,
  9   RNG   2     0   0.000E+00      B2(RNG):width of ring base, b2 (zero is a
 10   RNG   3     0   9.783E+00       H(RNG):height of stiffener (type H for s
 11   RNG   4     0   4.304E+00       W(RNG):width of outstanding flange of st
 12   RNG   3     1   5.673E-01    T(4 )(RNG):thickness for layer index no.(4 )
```

```
13   RNG   4     1   9.452E-01    T(5 )(RNG):thickness for layer index no.(5 )
Number of parameter to change (1, 2, 3, . .)=h

Choose an index from the left-most column in the above table.

Number of parameter to change (1, 2, 3, . .)=1
        1
New value of the parameter=10.110
  10.11000
Want to change any other parameters in this set?=y
y
PARAMETERS WHICH CAN BE CHANGED.   CHOOSE ONE OF THE FOLLOWING
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE             DEFINITION
 1         0     0   1.011E+01        B(STR):stiffener spacing, b: STR seg=NA,
 2   STR   2     0   3.370E+00       B2(STR):width of stringer base, b2 (must
 3   STR   3     0   7.817E+00        H(STR):height of stiffener (type H for s
 4   STR   4     0   2.534E+00        W(STR):width of outstanding flange of st
 5   SKN   1     1   7.690E-01    T(1 )(SKN):thickness for layer index no.(1 )
 6   STR   3     1   2.038E-01    T(2 )(STR):thickness for layer index no.(2 )
 7   STR   4     1   8.450E-02    T(3 )(STR):thickness for layer index no.(3 )
 8         0     0   3.185E+01        B(RNG):stiffener spacing, b: RNG seg=NA,
 9   RNG   2     0   0.000E+00       B2(RNG):width of ring base, b2 (zero is a
10   RNG   3     0   9.783E+00        H(RNG):height of stiffener (type H for s
11   RNG   4     0   4.304E+00        W(RNG):width of outstanding flange of st
12   RNG   3     1   5.673E-01    T(4 )(RNG):thickness for layer index no.(4 )
13   RNG   4     1   9.452E-01    T(5 )(RNG):thickness for layer index no.(5 )
Number of parameter to change (1, 2, 3, . .)=2
        2
New value of the parameter=3.3698
  3.369800
Want to change any other parameters in this set?=y
y
PARAMETERS WHICH CAN BE CHANGED.   CHOOSE ONE OF THE FOLLOWING
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE             DEFINITION
 1         0     0   1.011E+01        B(STR):stiffener spacing, b: STR seg=NA,
 2   STR   2     0   3.370E+00       B2(STR):width of stringer base, b2 (must
 3   STR   3     0   7.817E+00        H(STR):height of stiffener (type H for s
 4   STR   4     0   2.534E+00        W(STR):width of outstanding flange of st
 5   SKN   1     1   7.690E-01    T(1 )(SKN):thickness for layer index no.(1 )
 6   STR   3     1   2.038E-01    T(2 )(STR):thickness for layer index no.(2 )
 7   STR   4     1   8.450E-02    T(3 )(STR):thickness for layer index no.(3 )
 8         0     0   3.185E+01        B(RNG):stiffener spacing, b: RNG seg=NA,
 9   RNG   2     0   0.000E+00       B2(RNG):width of ring base, b2 (zero is a
10   RNG   3     0   9.783E+00        H(RNG):height of stiffener (type H for s
11   RNG   4     0   4.304E+00        W(RNG):width of outstanding flange of st
12   RNG   3     1   5.673E-01    T(4 )(RNG):thickness for layer index no.(4 )
13   RNG   4     1   9.452E-01    T(5 )(RNG):thickness for layer index no.(5 )
Number of parameter to change (1, 2, 3, . .)=3
        3
New value of the parameter=7.8167
  7.816700
Want to change any other parameters in this set?=y
y
PARAMETERS WHICH CAN BE CHANGED.   CHOOSE ONE OF THE FOLLOWING
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE             DEFINITION
 1         0     0   1.011E+01        B(STR):stiffener spacing, b: STR seg=NA,
 2   STR   2     0   3.370E+00       B2(STR):width of stringer base, b2 (must
 3   STR   3     0   7.817E+00        H(STR):height of stiffener (type H for s
 4   STR   4     0   2.534E+00        W(STR):width of outstanding flange of st
 5   SKN   1     1   7.690E-01    T(1 )(SKN):thickness for layer index no.(1 )
 6   STR   3     1   2.038E-01    T(2 )(STR):thickness for layer index no.(2 )
```

```
 7   STR   4     1   8.450E-02    T(3 )(STR):thickness for layer index no.(3 )
 8         0     0   3.185E+01        B(RNG):stiffener spacing, b: RNG seg=NA,
 9   RNG   2     0   0.000E+00       B2(RNG):width of ring base, b2 (zero is a
10   RNG   3     0   9.783E+00        H(RNG):height of stiffener (type H for s
11   RNG   4     0   4.304E+00        W(RNG):width of outstanding flange of st
12   RNG   3     1   5.673E-01    T(4 )(RNG):thickness for layer index no.(4 )
13   RNG   4     1   9.452E-01    T(5 )(RNG):thickness for layer index no.(5 )
Number of parameter to change (1, 2, 3, . .)=4
        4
New value of the parameter=2.5340
  2.534000
Want to change any other parameters in this set?=y
y
PARAMETERS WHICH CAN BE CHANGED.   CHOOSE ONE OF THE FOLLOWING
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE            DEFINITION
 1         0     0   1.011E+01        B(STR):stiffener spacing, b: STR seg=NA,
 2   STR   2     0   3.370E+00       B2(STR):width of stringer base, b2 (must
 3   STR   3     0   7.817E+00        H(STR):height of stiffener (type H for s
 4   STR   4     0   2.534E+00        W(STR):width of outstanding flange of st
 5   SKN   1     1   7.690E-01    T(1 )(SKN):thickness for layer index no.(1 )
 6   STR   3     1   2.038E-01    T(2 )(STR):thickness for layer index no.(2 )
 7   STR   4     1   8.450E-02    T(3 )(STR):thickness for layer index no.(3 )
 8         0     0   3.185E+01        B(RNG):stiffener spacing, b: RNG seg=NA,
 9   RNG   2     0   0.000E+00       B2(RNG):width of ring base, b2 (zero is a
10   RNG   3     0   9.783E+00        H(RNG):height of stiffener (type H for s
11   RNG   4     0   4.304E+00        W(RNG):width of outstanding flange of st
12   RNG   3     1   5.673E-01    T(4 )(RNG):thickness for layer index no.(4 )
13   RNG   4     1   9.452E-01    T(5 )(RNG):thickness for layer index no.(5 )
Number of parameter to change (1, 2, 3, . .)=5
        5
New value of the parameter=0.76896
 0.7689600
Want to change any other parameters in this set?=y
y
PARAMETERS WHICH CAN BE CHANGED.   CHOOSE ONE OF THE FOLLOWING
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE            DEFINITION
 1         0     0   1.011E+01        B(STR):stiffener spacing, b: STR seg=NA,
 2   STR   2     0   3.370E+00       B2(STR):width of stringer base, b2 (must
 3   STR   3     0   7.817E+00        H(STR):height of stiffener (type H for s
 4   STR   4     0   2.534E+00        W(STR):width of outstanding flange of st
 5   SKN   1     1   7.690E-01    T(1 )(SKN):thickness for layer index no.(1 )
 6   STR   3     1   2.038E-01    T(2 )(STR):thickness for layer index no.(2 )
 7   STR   4     1   8.450E-02    T(3 )(STR):thickness for layer index no.(3 )
 8         0     0   3.185E+01        B(RNG):stiffener spacing, b: RNG seg=NA,
 9   RNG   2     0   0.000E+00       B2(RNG):width of ring base, b2 (zero is a
10   RNG   3     0   9.783E+00        H(RNG):height of stiffener (type H for s
11   RNG   4     0   4.304E+00        W(RNG):width of outstanding flange of st
12   RNG   3     1   5.673E-01    T(4 )(RNG):thickness for layer index no.(4 )
13   RNG   4     1   9.452E-01    T(5 )(RNG):thickness for layer index no.(5 )
Number of parameter to change (1, 2, 3, . .)=6
        6
New value of the parameter=0.20380
 0.2038000
Want to change any other parameters in this set?=y
y
PARAMETERS WHICH CAN BE CHANGED.   CHOOSE ONE OF THE FOLLOWING
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE            DEFINITION
 1         0     0   1.011E+01        B(STR):stiffener spacing, b: STR seg=NA,
 2   STR   2     0   3.370E+00       B2(STR):width of stringer base, b2 (must
 3   STR   3     0   7.817E+00        H(STR):height of stiffener (type H for s
 4   STR   4     0   2.534E+00        W(STR):width of outstanding flange of st
```

```
 5   SKN   1     1   7.690E-01    T(1 )(SKN):thickness for layer index no.(1 )
 6   STR   3     1   2.038E-01    T(2 )(STR):thickness for layer index no.(2 )
 7   STR   4     1   8.450E-02    T(3 )(STR):thickness for layer index no.(3 )
 8         0     0   3.185E+01        B(RNG):stiffener spacing, b: RNG seg=NA,
 9   RNG   2     0   0.000E+00       B2(RNG):width of ring base, b2 (zero is a
10   RNG   3     0   9.783E+00        H(RNG):height of stiffener (type H for s
11   RNG   4     0   4.304E+00        W(RNG):width of outstanding flange of st
12   RNG   3     1   5.673E-01    T(4 )(RNG):thickness for layer index no.(4 )
13   RNG   4     1   9.452E-01    T(5 )(RNG):thickness for layer index no.(5 )
Number of parameter to change (1, 2, 3, . .)=7
        7
New value of the parameter=0.084496
 0.8449600E-01
Want to change any other parameters in this set?=y
y
PARAMETERS WHICH CAN BE CHANGED.   CHOOSE ONE OF THE FOLLOWING
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE            DEFINITION
 1         0     0   1.011E+01        B(STR):stiffener spacing, b: STR seg=NA,
 2   STR   2     0   3.370E+00       B2(STR):width of stringer base, b2 (must
 3   STR   3     0   7.817E+00        H(STR):height of stiffener (type H for s
 4   STR   4     0   2.534E+00        W(STR):width of outstanding flange of st
 5   SKN   1     1   7.690E-01    T(1 )(SKN):thickness for layer index no.(1 )
 6   STR   3     1   2.038E-01    T(2 )(STR):thickness for layer index no.(2 )
 7   STR   4     1   8.450E-02    T(3 )(STR):thickness for layer index no.(3 )
 8         0     0   3.185E+01        B(RNG):stiffener spacing, b: RNG seg=NA,
 9   RNG   2     0   0.000E+00       B2(RNG):width of ring base, b2 (zero is a
10   RNG   3     0   9.783E+00        H(RNG):height of stiffener (type H for s
11   RNG   4     0   4.304E+00        W(RNG):width of outstanding flange of st
12   RNG   3     1   5.673E-01    T(4 )(RNG):thickness for layer index no.(4 )
13   RNG   4     1   9.452E-01    T(5 )(RNG):thickness for layer index no.(5 )
Number of parameter to change (1, 2, 3, . .)=8
        8
New value of the parameter=31.850
  31.85000
Want to change any other parameters in this set?=y
y
PARAMETERS WHICH CAN BE CHANGED.   CHOOSE ONE OF THE FOLLOWING
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE            DEFINITION
 1         0     0   1.011E+01        B(STR):stiffener spacing, b: STR seg=NA,
 2   STR   2     0   3.370E+00       B2(STR):width of stringer base, b2 (must
 3   STR   3     0   7.817E+00        H(STR):height of stiffener (type H for s
 4   STR   4     0   2.534E+00        W(STR):width of outstanding flange of st
 5   SKN   1     1   7.690E-01    T(1 )(SKN):thickness for layer index no.(1 )
 6   STR   3     1   2.038E-01    T(2 )(STR):thickness for layer index no.(2 )
 7   STR   4     1   8.450E-02    T(3 )(STR):thickness for layer index no.(3 )
 8         0     0   3.185E+01        B(RNG):stiffener spacing, b: RNG seg=NA,
 9   RNG   2     0   0.000E+00       B2(RNG):width of ring base, b2 (zero is a
10   RNG   3     0   9.783E+00        H(RNG):height of stiffener (type H for s
11   RNG   4     0   4.304E+00        W(RNG):width of outstanding flange of st
12   RNG   3     1   5.673E-01    T(4 )(RNG):thickness for layer index no.(4 )
13   RNG   4     1   9.452E-01    T(5 )(RNG):thickness for layer index no.(5 )
Number of parameter to change (1, 2, 3, . .)=10
       10
New value of the parameter=9.7830
  9.783000
Want to change any other parameters in this set?=y
y
PARAMETERS WHICH CAN BE CHANGED.   CHOOSE ONE OF THE FOLLOWING
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE            DEFINITION
 1         0     0   1.011E+01        B(STR):stiffener spacing, b: STR seg=NA,
 2   STR   2     0   3.370E+00       B2(STR):width of stringer base, b2 (must
```

```
 3   STR   3     0   7.817E+00        H(STR):height of stiffener (type H for s
 4   STR   4     0   2.534E+00        W(STR):width of outstanding flange of st
 5   SKN   1     1   7.690E-01    T(1 )(SKN):thickness for layer index no.(1 )
 6   STR   3     1   2.038E-01    T(2 )(STR):thickness for layer index no.(2 )
 7   STR   4     1   8.450E-02    T(3 )(STR):thickness for layer index no.(3 )
 8         0     0   3.185E+01        B(RNG):stiffener spacing, b: RNG seg=NA,
 9   RNG   2     0   0.000E+00       B2(RNG):width of ring base, b2 (zero is a
10   RNG   3     0   9.783E+00        H(RNG):height of stiffener (type H for s
11   RNG   4     0   4.304E+00        W(RNG):width of outstanding flange of st
12   RNG   3     1   5.673E-01    T(4 )(RNG):thickness for layer index no.(4 )
13   RNG   4     1   9.452E-01    T(5 )(RNG):thickness for layer index no.(5 )
Number of parameter to change (1, 2, 3, . .)=11
       11
New value of the parameter=4.3037
  4.303700
Want to change any other parameters in this set?=y
y
PARAMETERS WHICH CAN BE CHANGED.   CHOOSE ONE OF THE FOLLOWING
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE            DEFINITION
 1         0     0   1.011E+01        B(STR):stiffener spacing, b: STR seg=NA,
 2   STR   2     0   3.370E+00       B2(STR):width of stringer base, b2 (must
 3   STR   3     0   7.817E+00        H(STR):height of stiffener (type H for s
 4   STR   4     0   2.534E+00        W(STR):width of outstanding flange of st
 5   SKN   1     1   7.690E-01    T(1 )(SKN):thickness for layer index no.(1 )
 6   STR   3     1   2.038E-01    T(2 )(STR):thickness for layer index no.(2 )
 7   STR   4     1   8.450E-02    T(3 )(STR):thickness for layer index no.(3 )
 8         0     0   3.185E+01        B(RNG):stiffener spacing, b: RNG seg=NA,
 9   RNG   2     0   0.000E+00       B2(RNG):width of ring base, b2 (zero is a
10   RNG   3     0   9.783E+00        H(RNG):height of stiffener (type H for s
11   RNG   4     0   4.304E+00        W(RNG):width of outstanding flange of st
12   RNG   3     1   5.673E-01    T(4 )(RNG):thickness for layer index no.(4 )
13   RNG   4     1   9.452E-01    T(5 )(RNG):thickness for layer index no.(5 )
Number of parameter to change (1, 2, 3, . .)=12
       12
New value of the parameter=0.56729
 0.5672900
Want to change any other parameters in this set?=y
y
PARAMETERS WHICH CAN BE CHANGED.   CHOOSE ONE OF THE FOLLOWING
VAR. STR/ SEG. LAYER   CURRENT
NO.  RNG  NO.   NO.     VALUE            DEFINITION
 1         0     0   1.011E+01        B(STR):stiffener spacing, b: STR seg=NA,
 2   STR   2     0   3.370E+00       B2(STR):width of stringer base, b2 (must
 3   STR   3     0   7.817E+00        H(STR):height of stiffener (type H for s
 4   STR   4     0   2.534E+00        W(STR):width of outstanding flange of st
 5   SKN   1     1   7.690E-01    T(1 )(SKN):thickness for layer index no.(1 )
 6   STR   3     1   2.038E-01    T(2 )(STR):thickness for layer index no.(2 )
 7   STR   4     1   8.450E-02    T(3 )(STR):thickness for layer index no.(3 )
 8         0     0   3.185E+01        B(RNG):stiffener spacing, b: RNG seg=NA,
 9   RNG   2     0   0.000E+00       B2(RNG):width of ring base, b2 (zero is a
10   RNG   3     0   9.783E+00        H(RNG):height of stiffener (type H for s
11   RNG   4     0   4.304E+00        W(RNG):width of outstanding flange of st
12   RNG   3     1   5.673E-01    T(4 )(RNG):thickness for layer index no.(4 )
13   RNG   4     1   9.452E-01    T(5 )(RNG):thickness for layer index no.(5 )
Number of parameter to change (1, 2, 3, . .)=13
       13
New value of the parameter=0.94524
 0.9452400
Want to change any other parameters in this set?=n
n
Do you want to change values of "fixed" parameters?=n
n
Do you want to change values of allowables?=n
```

```
 n

 DESCRIPTION OF FILES GENERATED BY THIS CASE:
 cylstif.CHG = Summary of interactive session you have just
          completed. This file can be edited and used for
          future runs of CHANGE.
 cylstif.CBL = Contains part of cylstif data base.
 cylstif.OPC = Output from CHANGE. Please list this file and
          inspect it and the cylstif.CHG file carefully before
          proceeding.
 For further information about files generated during operation
 of PANDA2 give the command HELPAN FILES.
 Next, give the commands  SETUP, etc.   .
-------- end of the "CHANGE" interactive session --------------


The input for the "CHANGE" interactive session are saved in
the file, cylstif.CHG. A list of this file follows:

------ list of the file, cylstif.CHG (input for CHANGE) ------

      n          $ Do you want a tutorial session and tutorial output?
      y          $ Do you want to change any values in Parameter Set No. 1?
         1       $ Number of parameter to change (1, 2, 3, . .)
   10.11000      $ New value of the parameter
      y          $ Want to change any other parameters in this set?
         2       $ Number of parameter to change (1, 2, 3, . .)
   3.369800      $ New value of the parameter
      y          $ Want to change any other parameters in this set?
         3       $ Number of parameter to change (1, 2, 3, . .)
   7.816700      $ New value of the parameter
      y          $ Want to change any other parameters in this set?
         4       $ Number of parameter to change (1, 2, 3, . .)
   2.534000      $ New value of the parameter
      y          $ Want to change any other parameters in this set?
         5       $ Number of parameter to change (1, 2, 3, . .)
  0.7689600      $ New value of the parameter
      y          $ Want to change any other parameters in this set?
         6       $ Number of parameter to change (1, 2, 3, . .)
  0.2038000      $ New value of the parameter
      y          $ Want to change any other parameters in this set?
         7       $ Number of parameter to change (1, 2, 3, . .)
  0.8449600E-01 $ New value of the parameter
      y          $ Want to change any other parameters in this set?
         8       $ Number of parameter to change (1, 2, 3, . .)
   31.85000      $ New value of the parameter
      y          $ Want to change any other parameters in this set?
        10       $ Number of parameter to change (1, 2, 3, . .)
   9.783000      $ New value of the parameter
      y          $ Want to change any other parameters in this set?
        11       $ Number of parameter to change (1, 2, 3, . .)
   4.303700      $ New value of the parameter
      y          $ Want to change any other parameters in this set?
        12       $ Number of parameter to change (1, 2, 3, . .)
  0.5672900      $ New value of the parameter
      y          $ Want to change any other parameters in this set?
        13       $ Number of parameter to change (1, 2, 3, . .)
  0.9452400      $ New value of the parameter
      n          $ Want to change any other parameters in this set?
      n          $ Do you want to change values of "fixed" parameters?
      n          $ Do you want to change values of allowables?
-------- end of the list of the input file, cylstif.CHG -------------
```

The file, cylstif.CHG, represents an archive of the optimum design.
It can be used in the future to re-establish that optimum design.

PART 1.16: Execute the PANDA2 processors called "SETUP", "MAINSETUP", and "PANDAOPT" again in order to verify that the archive file, cylstif.CHG, is correct.

bush-> setup

```
Enter case name: cylstif

 (Output from SETUP rolls by fast on the screen)
```

bush-> mainsetup

```
Please enter PANDA2 case name: cylstif

  *****************   MAINSETUP   ****************
 The purpose of this processor is to permit you to choose loads
 and initial imperfections, Nx, Ny, Nxy, Mx, My, Nxo, Nyo, p,
 T(iseg), Wimp(global), Wimp(local),  (up to 5 sets of them);
 safety factors for general instability, panel instability,
 local instability (panel skin), local instability (stiffener
 parts), and stress; and strategy parameters for subsequent
 batch execution of an optimization analysis (analysis type 1);
 or an analysis of a fixed design at fixed load levels
 (analysis type 2); or an analysis of a fixed design for a
 single load set for monotonically increasing load levels
 (test simulation: analysis type 3).

 Results of the interactive session in MAINSETUP are saved on a
 file called cylstif.OPT, which will appear at the beginning of
 the cylstif.OPM file when the mainprocessor batch run launched
 by your command PANDAOPT has been completed.

 NOTE: JUST HIT "RETURN" FOR DEFAULT VALUE OF INPUT DATUM. IF
   PANDA2 REQUIRES AN INPUT, IT WILL SAY "PLEASE SAY SOMETHING"
  ***************************************************

 Are you correcting, adding to, or using an existing file?=y

 (Output from MAINSETUP rolls by fast on the screen)
```

bush-> pandaopt

```
The purpose of PANDAOPT is to launch the batch run which performs
optimization or buckling according to the strategy parameters
established the last time you did a MAINSETUP. Output from PANDAOPT
is stored in a file called casename.OPM, in which casename is
the name of the case. You will want to examine casename.OPM as soon
as PANDAOPT is finished.

Enter case name: cylstif
B (background), F (foreground), or Q (NQS - network queue system): f

Running PANDA2: pandaopt, case: cylstif

Executing main
Normal termination: main
```

```
still processing... Please wait.
Executing store
Normal termination: store
still processing... Please wait.
cylstif mainprocessor run completed successfully.
Menu: PANDAOPT, CHOOSEPLOT, MAINSETUP, CHANGE
Please examine the files: cylstif.OPM, cylstif.OPP, and cylstif.OPI
If ITYPE=1, print the file called cylstif.OPP
If ITYPE=3 or 4, print the file called cylstif.OPI
Run PANDAOPT several times for optimization.
```

(Inspect the cylstif.OPM file to make sure that your input data for CHANGE are correct: compare the cylstif.OPM file with the cylstif.OPM file listed above. Make sure that the margins and weight and values of the decision variables are essentially the same as before. NOTE: very small margins may differ in the signficant figures, but that does not matter, as long as they remain very small.)

PART 1.17: Execute the PANDA2 processors called "MAINSETUP" and "PANDAOPT" again, this time for the perfect shell

Next, edit the input for MAINSETUP, the file, cylstif.OPT, to set the general buckling modal imperfction equal to zero, as follows:

```
 0.0  $ Initial buckling modal general imperfection amplitude, Wimpg2(1)
```

and run MAINSETUP and PANDAOPT again for the same fixed, optimized design. Why do we do this? Because afterward we intend to run BIGBOSOR4 in order to verify the PANDA2 predictions, and BIGBOSOR4 cannot handle non-axisymmetric buckling modal imperfection shapes.

bush-> mainsetup

```
Please enter PANDA2 case name: cylstif

  *****************   MAINSETUP   ****************
 The purpose of this processor is to permit you to choose loads
 and initial imperfections, Nx, Ny, Nxy, Mx, My, Nxo, Nyo, p,
 T(iseg), Wimp(global), Wimp(local),  (up to 5 sets of them);
 safety factors for general instability, panel instability,
 local instability (panel skin), local instability (stiffener
 parts), and stress; and strategy parameters for subsequent
 batch execution of an optimization analysis (analysis type 1);
 or an analysis of a fixed design at fixed load levels
 (analysis type 2); or an analysis of a fixed design for a
 single load set for monotonically increasing load levels
 (test simulation: analysis type 3).

 Results of the interactive session in MAINSETUP are saved on a
 file called cylstif.OPT, which will appear at the beginning of
 the cylstif.OPM file when the mainprocessor batch run launched
 by your command PANDAOPT has been completed.

 NOTE: JUST HIT "RETURN" FOR DEFAULT VALUE OF INPUT DATUM. IF
   PANDA2 REQUIRES AN INPUT, IT WILL SAY "PLEASE SAY SOMETHING"
  ***************************************************
```

```
 Are you correcting, adding to, or using an existing file?=y

 (The input for MAINSETUP rolls by fast.)
```

bush-> pandaopt

```
The purpose of PANDAOPT is to launch the batch run which performs
optimization or buckling according to the strategy parameters
established the last time you did a MAINSETUP. Output from PANDAOPT
is stored in a file called casename.OPM, in which casename is
the name of the case. You will want to examine casename.OPM as soon
as PANDAOPT is finished.

Enter case name: cylstif
B (background), F (foreground), or Q (NQS - network queue system): f

Running PANDA2: pandaopt, case: cylstif

Executing main
Normal termination: main
still processing... Please wait.
Executing store
Normal termination: store
still processing... Please wait.
cylstif mainprocessor run completed successfully.
Menu: PANDAOPT, CHOOSEPLOT, MAINSETUP, CHANGE
Please examine the files: cylstif.OPM, cylstif.OPP, and cylstif.OPI
If ITYPE=1, print the file called cylstif.OPP
If ITYPE=3 or 4, print the file called cylstif.OPI
Run PANDAOPT several times for optimization.
```

PART 1.18: Inspect the output from PANDAOPT: the cylstif.OPM file

```
Only the new margins in the new cylstif.OPM file are
listed here:

------------ abridged cylstif.OPM file for perfect shell -----------------

 MARGINS FOR CURRENT DESIGN: LOAD CASE NO. 1, SUBCASE NO. 1  (between rings)
 MAR. MARGIN
 NO.  VALUE                DEFINITION
 1   8.67E-02 Local buckling from discrete model-1.,M=1   axial halfwaves;FS=1.1
 2   8.67E-02 Bending-torsion buckling; M=1  ;FS=1.1
 3   2.73E-01 eff.stress:matl=1,SKN,Dseg=2,node=6,layer=1,z=0.3845; MID.;FS=1.
 4   1.05E-01 (m=1   lateral-torsional buckling load factor)/(FS)-1;FS=1.1
 5   1.12E-01 Inter-ring bucklng, discrete model, n=32  circ.halfwaves;FS=1.1
 6   5.82E-01 Lo-n Ring sidesway, discrete model, n=4   circ.halfwaves;FS=1.1
 7   2.73E-01 eff.stress:matl=1,SKN,Iseg=2,at:n=6,layer=1,z=0.3845;-MID.;FS=1.
 8   6.93E-01 buckling margin stringer Iseg.3 . Local halfwaves=4  .MID.;FS=1.
 9   2.50E-01 buckling margin stringer Iseg.4 . Local halfwaves=4  .MID.;FS=1.
10   2.02E-01 buckling stringer Isegs.3+4 together.M=4  ;C=0.     ;MID.;FS=1.4
11   8.77E+00 buckling stringer Iseg 4 as beam on foundation. M=369;MID.;FS=1.2
12   1.44E+00 buckling margin   ring   Iseg.3 . Local halfwaves=32 .MID.;FS=1.
13   1.06E+01 buckling   ring   Iseg 4 as beam on foundation. M=67 ;MID.;FS=1.2
14   8.79E-01 buck.(SAND);simp-support general buck;M=1;N=3;slope=0.;FS=1.1
15   1.76E+01 buck.(SAND);rolling with smear rings; M=93;N=1;slope=0.;FS=1.1
16   4.18E-01 buck.(SAND);rolling only of stringers;M=8;N=0;slope=0.;FS=1.4
17   1.28E+00 buck.(SAND);hiwave roll. of stringers;M=54;N=0;slope=0.;FS=1.2
```

```
18  6.12E-01 buck.(SAND);rolling only axisym.rings;M=0;N=0;slope=0.;FS=1.4
19  6.93E-01 buck.(SAND); STRINGERS:  web buckling;M=4;N=1;slope=0.;FS=1.
20  1.42E+00 buck.(SAND);   RINGS:    web buckling;M=26;N=1;slope=0.;FS=1.
21  6.93E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.


 MARGINS FOR CURRENT DESIGN: LOAD CASE NO. 1, SUBCASE NO. 2  (at rings)
 MAR. MARGIN
 NO.  VALUE                DEFINITION
 1  8.67E-02 Local buckling from discrete model-1.,M=1   axial halfwaves;FS=1.1
 2  1.95E-01 Bending-torsion buckling; M=1  ;FS=1.
 3  4.01E-01 eff.stress:matl=1,STR,Dseg=5,node=11,layer=1,z=0.3845; RNGS;FS=1.
 4  1.05E-01 (m=1   lateral-torsional buckling load factor)/(FS)-1;FS=1.1
 5  1.12E-01 Inter-ring bucklng, discrete model, n=32  circ.halfwaves;FS=1.1
 6  5.82E-01 Lo-n Ring sidesway, discrete model, n=4   circ.halfwaves;FS=1.1
 7  4.01E-01 eff.stress:matl=1,SKN,Iseg=2,at:n=6,layer=1,z=0.3845;-RNGS;FS=1.
 8  6.93E-01 buckling margin stringer Iseg.3 . Local halfwaves=4  .RNGS;FS=1.
 9  2.50E-01 buckling margin stringer Iseg.4 . Local halfwaves=4  .RNGS;FS=1.
10  2.02E-01 buckling stringer Isegs.3+4 together.M=4  ;C=0.     ;RNGS;FS=1.4
11  8.77E+00 buckling stringer Iseg 4 as beam on foundation. M=369;RNGS;FS=1.2
12  1.44E+00 buckling margin   ring   Iseg.3 . Local halfwaves=32 .RNGS;FS=1.
13  1.06E+01 buckling   ring   Iseg 4 as beam on foundation. M=67 ;RNGS;FS=1.2
14  1.76E+01 buck.(SAND);rolling with smear rings; M=93;N=1;slope=0.;FS=1.1
15  4.18E-01 buck.(SAND);rolling only of stringers;M=8;N=0;slope=0.;FS=1.4
16  1.28E+00 buck.(SAND);hiwave roll. of stringers;M=54;N=0;slope=0.;FS=1.2
17  6.12E-01 buck.(SAND);rolling only axisym.rings;M=0;N=0;slope=0.;FS=1.4
18  6.93E-01 buck.(SAND); STRINGERS:  web buckling;M=4;N=1;slope=0.;FS=1.
19  1.42E+00 buck.(SAND);   RINGS:    web buckling;M=26;N=1;slope=0.;FS=1.
20  6.93E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
 ***********  ALL 1 LOAD SETS PROCESSED  ***********

--------- end of abridged cylstif.OPM file for perfect shell -----------
```

Compare with the margins listed previously for the optimized imperfect shell. (See PART 1.14)

PART 1.19: Selected output from the cylstif.OPM file obtained when the output index, NPRINT = 2, in the cylstif.OPT file

This section is quite long, but it is important as it demonstrates:
1. What sort of calculations PANDA2 performs, and
2. What the predictions are obtained from certain of the "CHAPTERS", as listed next.

Here follows some selected output contained in the cylstif.OPM file for the perfect shell included when the print index, NPRINT = 2, in the *.OPT (cylstif.OPT) file (*.OPT = input for MAINSETUP).

NOTE: There appear below some references to previously published papers, notations such as "[1K]", "[1L]", etc. These designations occur in Reference 1 of the following paper:

ANOTHER NOT: The string, "t.s.d." occurs:
"t.s.d." = "transverse shear deformation"

Bushnell, D.
"Optimization of an axially compressed ring and stringer stiffened cylindrical shell with a general buckling modal imperfection", AIAA Paper 2007-2216, 48th AIAA SDM Meeting, Honolulu, Hawaii, April 2007

```
(lines skipped to save space)

CHAPTER 1  Compute the 6 x 6 constitutive matrices [C] for
           individual model segments and various combinations
           thereof (skin with smeared stiffener sets [1A]).
           See Section 8 in [1A], Eq.(8.1) on p.495 of [1A].

(lines skipped to save space)

CHAPTER 2  Do PANDA-type [1B] general buckling analysis to
           get Donnell factors for later use, if appropriate.

(lines skipped to save space)

CHAPTER 3  Do various PANDA-type [1B] general buckling
           analyses needed for later computation of effective
           length of the panel. Compute the effective length.

(lines skipped to save space)

CHAPTER NEW Compute wide-column buckling from discretized
           skin-stringer module model (Figs. 20b,c & 22b,c in
           [1A]) with only Nx (Ny=0, Nxy=0). The purpose is to
           obtain a knockdown factor, WIDKNK, for smearing
           the stringers in an inter-ring buckling mode

(lines skipped to save space)

CHAPTER NEW1 Compute distribution of loads in panel module
           skin-stringer segments, neglecting redistribution
           due to initial buckling modal imperfections
           (See Section 10 of [1A]). These loads are for
           computing a preliminary value of wide column
           buckling, needed for smeared stringer knockdown.

(lines skipped to save space)

CHAPTER NEW2 List prebuckling stress resultants, Nx, Ny,
       needed for the discretized single-module skin-stringer
       model used for a preliminary value of wide column
       buckling (BOSOR4-type model: see Figs. 18, 20,
       22, 97, and 98 of [1A], for examples of the
       discretized single skin-stringer BOSOR4-type
       module model.). This distribution of Nx is used in
       the wide column model used to obtain the smeared
       stringer knockdown factor, WIDKNK. Ny and Nxy and the
       fixed (non-eigenvalue) loads, Nxo, Nyo, Nxyo are set
       to zero for this computation of wide column buckling.

(lines skipped to save space)

CHAPTER NEW3 Do wide-column inter-ring buckling analysis.
           (See Figs. 20c, 22c, 46d, and 67 of [1A],
           for examples.). The purpose of this computation
           is to obtain a smeared stringer knockdown factor.

(lines skipped to save space)

Mode number  2 IS a wide column mode and is therefore acceptable.
*** END OF PRELIMINARY WIDE COLUMN BUCKLING CALCULATIONS ***

SMEARED STRINGER KNOCKDOWN FROM SKIN-STRINGER DISCRETE MODEL
```

```
(See ..panda2/doc/panda2.news Items 724 and 725):
Buckling axial resultant Nx from simple Euler model,   EULER =  4.7211E+05
Buckling axial resultant Nx from discretized  model,   EIGWID=  2.3590E+05
Knockdown factor for cross section rigidity & t.s.d.,  WIDKNK=  4.9966E-01
Effective axial length of the wide column model,       AXLEFF=  3.1850E+01

(lines skipped to save space)

CHAPTER 4  Compute axisymmetric prebuckling "hungry-horse"
           state of the curved panel or cylindrical shell.
           (See Ref.[1E], especially Fig. 1 and pp.495-498).

(lines skipped to save space)

CHAPTER 5  Get static response of panel to normal pressure
           [1A], especially Section 9 and Section 20.5 and
           Figs. 55 - 60 in [1A].

(lines skipped to save space)

CHAPTER 6  Do PANDA-type [1B] general and inter-ring buckling
           analyses to permit later computation of
           amplification of panel bowing.

(lines skipped to save space)

CHAPTER 7  Compute distribution of loads in panel module
           skin-stringer segments, neglecting redistribution
           due to initial buckling modal imperfections
           (See Section 10 of [1A]).

(lines skipped to save space)

CHAPTER 8  Do PANDA-type local, inter-ring, general buckling
           analyses and PANDA-type stringer web and ring web
           buckling analyses to get knockdown factors to
           compensate for lack of in-plane shear Nxy loading
           and anisotropy in discretized BOSOR4-type models.
           (See Section 11 of [1A] and Item No. 81 in [1L]).

(lines skipped to save space)

CHAPTER 9  Do BOSOR4-type "skin"-ring buckling analyses to
           compute knockdown factor to compensate for
           inherent unconservativeness of models with
           smeared rings. (See Items 509, 511, 522, and
           605 in [1L]; "skin"=skin+smeared stringers).

(lines skipped to save space)

Knockdown for smeared rings on cylindrical shell...
 Buckling load factor for n+dn = FNARCQ=  3.0000E+00
                              from discrete model =  1.8086E+00
 Buckling load factor for ring with bending stiffness EI:
                     pcrit=[(n+dn)**2-1]*EI/r**3/p=  2.4315E+00
 Knockdown factor, general buckling,   EIGR/EIGRNG=  7.4385E-01
END OF SECTION ON GENERATION OF KNOCKDOWN FACTOR FOR
COMPENSATING FOR THE UNCONSERVATIVENESS OF SMEARING RINGS
----------------------------------------------------------


Knockdown for smeared rings, RNGKNZ=  9.0000E-01(FNARCQ=  3.0000E+00)

(lines skipped to save space)
```

```
CHAPTER 10 Compute knockdown factors and prebuckling bending
           associated with initial general, inter-ring, local
           buckling modal imperfections. (See Ref.[1E].
           Also see Sections 13 and 14 and Tables 9 and 10
           of Ref.[1K]).

(lines skipped to save space)

CHAPTER 10.1 Compute knockdown factor and prebuckling bending
             associated with GENERAL buckling modal initial
             imperfection. (See Sectons 13 and 14 and
             Tables 9 and 10 of [1K] for a detailed example)

(lines skipped to save space)

CHAPTER 10.2 Compute knockdown factor and prebuckling bending
             associated with INTER-RING buckling modal
             initial imperfection.

(lines skipped to save space)

CHAPTER 10.3 Compute knockdown factor and prebuckling bending
             associated with LOCAL buckling modal initial
             imperfection.

(lines skipped to save space)

CHAPTER 10.4 Present a summary of imperfection sensitivity
             results. (See Section 13 and Table 9 of [1K])

(lines skipped to save space)

==========================================================
BUCKLING LOAD FACTORS AND IMPERFECTION SENSITIVITY SUMMARY
----------------------------------------------------------
                         LOCAL     INTER-RING      GENERAL
                       BUCKLING     BUCKLING      BUCKLING
RATIOS OF BUCKLING LOADS FROM ARBOCZ THEORY TO THOSE FROM
PANDA2 THEORY FOR THE PERFECT STRUCTURE:
   (ARBOCZ/PANDA2):   1.0000E+00   1.0000E+00   1.0000E+00
----------------------------------------------------------
KNOCKDOWN FACTORS FOR IMPERFECTIONS DERIVED FROM
PANDA2 THEORY VS THOSE FROM ARBOCZ 1992 UPDATE OF KOITERs
1963 SPECIAL THEORY:
FROM PANDA2 THEORY:   1.0000E+00   1.0000E+00   1.0000E+00
FROM ARBOCZ THEORY:   1.0000E+00   1.0000E+00   1.0000E+00
THE GOVERNING KNOCKDOWN FACTOR FOR EACH TYPE OF BUCKLING
(LOCAL, INTER-RING, GENERAL) IS SET EQUAL TO THE MINIMUM
KNOCKDOWN FACTOR FOR THAT TYPE OF BUCKLING, REDUCED
FURTHER BY THE RATIO (ARBOCZ/PANDA2) FOR THE PERFECT PANEL
IF THE RATIO (ARBOCZ/PANDA2) IS LESS THAN UNITY:
The ARBOCZ theory is used only if ICONSV=1. ICONSV= 1

USED NOW IN PANDA2:   1.0000E+00   1.0000E+00   1.0000E+00

FACTOR APPLIED TO   1.0000E+00 FOR ALTERNATIVE SOLUTION FOR
GENERAL    BUCKLING WITH DISCRETE STIFFENERS, FKNMLT=  1.0000E+00
FACTOR APPLIED TO   1.0000E+00 FOR ALTERNATIVE SOLUTION FOR
INTER-RING BUCKLING WITH DISCRETE STIFFENERS, FKNMLS=  1.0000E+00

***NOTE*** IF THERE IS INTERNAL PRESSURE THESE KNOCKDOWN
           FACTORS MAY BE CHANGED AS NOTED BELOW.
==========================================================
```

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CHAPTER 11 Get change in stress resultants, Nx, Ny, Nxy in various segments of the skin-stringer module during prebuckling bending of the imperfect shell. Also, do PANDA-type [1B] local, inter-ring, general buckling analyses and PANDA-type stringer web and ring web buckling analyses to get knockdown factors to compensate for the lack of in-plane shear Nxy loading and anisotropy in discretized BOSOR4-type models. (See Section 11 in [1A])

(lines skipped to save space)

CHAPTER 12 Obtain prebuckled state of the initially imperfect and loaded and bent panel or shell. This section includes the redistribution of Nx, Ny, Nxy in the various segments of the stiffened shell structure.

(lines skipped to save space)

CHAPTER 13 Get prebuckling stress resultants, Nx, Ny, needed for the discretized single-module skin-stringer model used for local buckling and bending-torsion buckling (BOSOR4-type model: see Figs. 18, 20, 22, 97, and 98 of [1A], for examples of the discretized single skin-stringer BOSOR4-type module model.).

(lines skipped to save space)

CHAPTER 14 Compute local buckling from BOSOR4-type discretized skin-stringer single module model. See Section 12.2 (upper table on p. 511) and Figs. 46c and 98b in [1A], for examples.

```
BUCKLING LOAD FACTORS FROM BOSOR4-TYPE DISCRETIZED MODEL...
         (skin-stringer discretized module of local buckling)
 AXIAL     BUCKLING        KNOCKDOWN FOR    KNOCKDOWN FOR      BUCKLING
 HALF-    LOAD FACTOR     TRANSVERSE SHEAR  IN-PLANE SHEAR    LOAD FACTOR
 WAVES  BEFORE KNOCKDOWN    DEFORMATION     LOADING AND/OR  AFTER KNOCKDOWN
                                              ANISOTROPY
   M        EIGOLD             KSTAR            KNOCK     EIGOLD*KSTAR*KNOCK
   3      2.43710E+00       1.00000E+00      1.00000E+00     2.43710E+00
   4      2.22611E+00       1.00000E+00      1.00000E+00     2.22611E+00
   5      2.13420E+00       1.00000E+00      1.00000E+00     2.13420E+00
   6      2.22328E+00       1.00000E+00      1.00000E+00     2.22328E+00
Buckling load factor before t.s.d.=  2.1342E+00 After t.s.d.=  2.0666E+00
```

(lines skipped to save space)

```
BUCKLING LOAD FACTORS FROM BOSOR4-TYPE DISCRETIZED MODEL...
         (skin-stringer discretized module of local buckling)
 AXIAL     BUCKLING        KNOCKDOWN FOR    KNOCKDOWN FOR      BUCKLING
 HALF-    LOAD FACTOR     TRANSVERSE SHEAR  IN-PLANE SHEAR    LOAD FACTOR
 WAVES  BEFORE KNOCKDOWN    DEFORMATION     LOADING AND/OR  AFTER KNOCKDOWN
                                              ANISOTROPY
   M        EIGOLD             KSTAR            KNOCK     EIGOLD*KSTAR*KNOCK
   1      1.21563E+00       9.83375E-01      1.00000E+00     1.19542E+00
```

(lines skipped to save space)

 ****

```
 **** LOCAL MODE HAS STRINGER SIDESWAY ****
 ******************************************
 **** END OF LOCAL BUCKLING EIGENVECTOR CALC.****
IPANDA= 0
Margin=  8.6749E-02  Local buckling from discrete model-1.,M=1   axial halfwaves;FS=1.1
Margin=  8.6749E-02  Bending-torsion buckling; M=1  ;FS=1.1

(lines skipped to save space)

CHAPTER 15 Compute bending-torsion (low-m) buckling from
           BOSOR4-type discretized skin-stringer single
           module model. See Section 12.2 (lower table on
           p. 511) in [1A], for example.

(lines skipped to save space)

CHAPTER 16 Compute post-local buckling from the Koiter
           theory given in Ref.[1C]. See Figs. 23, 24, and
           Figs. 47-49 in [1A], Fig. 6 in [1C], and Fig. 4 in
Bushnell, D.
"Optimization of an axially compressed ring and stringer
stiffened cylindrical shell with a general buckling modal
imperfection", AIAA Paper 2007-2216, 48th AIAA SDM Meeting,
Honolulu, Hawaii, April 2007

(lines skipped to save space)

Skipping the NONLINEAR PART of the KOITER posbuckling
analysis because the user indicates in the *.OPT file that
he/she wants to skip it and because IICURV=1 (panel skin is
curved in the single discretized skin-stringer module model).

(lines skipped to save space)

LOCAL BIFURCATION BUCKLING LOAD FACTOR ESTIMATES
AND AMPLITUDE Wo OF LOCAL IMPERFECTION, Wo*(buckling mode)
Critical number of axial half-waves                 =  1
Slope of buckling nodal lines from Koiter Theory, m=  1.71E-03
Knockdown factor for C44, C45, C55 for transv.shear=  9.83E-01
Local buckling load Factor from Koiter-type Theory =  1.21E+00
Load Factor from BOSOR4-type panel module model    =  1.20E+00
BOSOR4-type load factor without knockdowns for
  effects of anisotropy [e.g. C(4,6)] of the skin,
  transverse shear def., or in-plane shear loading =  1.22E+00
Amplitude Wo of local imperfection                 =  3.8448E-02

(lines skipped to save space)

CHAPTER 17 Compute stresses in layers and at various
           locations in skin-stringer module model, including
           local post-buckling, if any. Compute stringer
           popoff constraints (Figs. 5 - 7 in [1A]). Local
           post-buckling such as that shown in Figs. 48 & 49
           of [1A] is included. Therefore, SUBROUTINE STRTHK
           is used.

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Margin=  2.7265E-01  eff.stress:matl=1,SKN,Dseg=2,node=6,layer=1,z=0.3845; MID.;FS=1.

(lines skipped to save space)

CHAPTER 18 Present summary of state of loaded imperfect panel
           and give effective stiffnesses of possibly locally
```

```
           postbuckled skin-stringer module. These effective
           stiffnesses are used later for overall buckling
           and inter-ring buckling. See Table 12 in the paper
Bushnell, D.
"Optimization of an axially compressed ring and stringer
stiffened cylindrical shell with a general buckling modal
imperfection", AIAA Paper 2007-2216, 48th AIAA SDM Meeting,
Honolulu, Hawaii, April 2007

(lines skipped to save space)

CHAPTER 19 Do wide-column inter-ring buckling analysis with
           possibly locally postbuckled skin-stringer module
           model. (See Figs. 20c, 22c, 46d, and 67 of [1A],
           for examples.).

(lines skipped to save space)

CHAPTER 20 Compute width-wise wide column buckling and
           lateral-torsional buckling load factors from the
           possibly locally postbuckled skin-stringer module
           model (inter-ring buckling modes).
           See panda2.news Item Numbers 379 and 381 in [1L].

(lines skipped to save space)

CHAPTER 21 Compute "skin"-ring buckling load factor for
           computing knockdown to compensate for inherent
           unconservativeness of smeared ring models.
           (See bottom row in Fig. 30 of Ref.[1G]. Also see
           panda2.news Items 509, 511, 522, 532, 605, 617
           619, 632, 633, 676.

(lines skipped to save space)

Knockdown for smeared rings on cylindrical shell...
 Buckling load factor for n+dn = FNARCQ=  3.0000E+00
                              from discrete model =  1.8086E+00
 Buckling load factor for ring with bending stiffness EI:
                     pcrit=[(n+dn)**2-1]*EI/r**3/p=  2.4315E+00
 Knockdown factor, general buckling,   EIGR/EIGRNG=  7.4384E-01

Knockdown for smeared rings, RNGKNK=  9.0000E-01(FNARCQ=  3.0000E+00)

(lines skipped to save space)

CHAPTER 22 Compute "skin"-ring buckling load factors for:
           1. medium-n inter-ring buckling mode (See
              rightmost three mode shapes in top row of
              Fig. 30 of Ref.[1G]),
           2. high-n inter-ring buckling mode (See rightmost
              mode shape in middle row of Fig. 30, Ref.[1G]),
           3. low-n inter-ring buckling mode (See leftmost
              mode shape in top row of Fig. 30, Ref.[1G]).

(lines skipped to save space)

BUCKLING LOAD FACTORS FROM BOSOR4-TYPE DISCRETIZED MODEL...
          (skin-smeared-stringer-ring discretized module)
 HOOP      BUCKLING        KNOCKDOWN FOR    KNOCKDOWN FOR      BUCKLING
 HALF-    LOAD FACTOR     TRANSVERSE SHEAR  IN-PLANE SHEAR    LOAD FACTOR
 WAVES  BEFORE KNOCKDOWN    DEFORMATION     LOADING AND/OR  AFTER KNOCKDOWN
                                              ANISOTROPY
   n        EIGOLD             KSTAR            KNOCK     EIGOLD*KSTAR*KNOCK
```

```
  32      2.44726E+00       1.00000E+00      1.00000E+00     2.44726E+00
  35      2.48779E+00       1.00000E+00      1.00000E+00     2.48779E+00
  29      2.47892E+00       1.00000E+00      1.00000E+00     2.47892E+00
Buckling load factor before t.s.d.=  2.4473E+00 After t.s.d.=  2.2273E+00

(lines skipped to save space)

knockdown for smeared stringers from SUB.EIGMOD,
                                         SMRFAC=  5.4900E-01
knockdown for transverse shear deformation (t.s.d.) from SUB.SHRRED,
                                         SHRFAC=  9.1013E-01
Buckling load factor BEFORE knockdown for smeared stringers=  2.2273E+00
Buckling load factor AFTER  knockdown for smeared stringers=  1.2228E+00

(lines skipped to save space)

Margin=  1.1164E-01  Inter-ring bucklng, discrete model, n=32  circ.halfwaves;FS=1.1

(lines skipped to save space)

Margin=  5.8244E-01  Lo-n Ring sidesway, discrete model, n=4   circ.halfwaves;FS=1.1

(lines skipped to save space)

CHAPTER 23 Compute stresses in layers and at various
           locations in modules for both positive and
           negative imperfection amplitudes from SUBROUTINE
           STRCON (local postbuckling neglected). See [1L]
           (panda2.news) Items 36b,d,w, 41b, and Section E
           of Table 122.6 in Item 122.

(lines skipped to save space)

Margin=  2.7265E-01  eff.stress:matl=1,SKN,Iseg=2,at:n=6,layer=1,z=0.3845;-MID.;FS=1.

(lines skipped to save space)

CHAPTER 24 Present short summary of redistribution of stress
           resultants, Nx, Ny, Nxy, caused by prebuckling
           bending of an initially imperfect shell.
           See Section 6.0 in [1K], for example.

Additional resultants (Nx,Ny) in panel skin from
global and inter-ring bending of imperfect panel:
           Additional axial resultant, dNx = -2.8206E-05
           Additional  hoop resultant, dNy =  0.0000E+00
  Additional in-plane shear resultant, dNxy=  0.0000E+00

Additional axial resultants dNx along webs and flanges of
stringers from global and inter-ring bending of imperfect panel:
    Additional Nx in  base  of stringer, dNx = -2.8206E-05
    Additional Nx at webtip of stringer, dNx = -6.6356E-05
    Additional Nx in flange of stringer, dNx = -2.7511E-05

Additional axial resultants dNx along webs and flanges of
rings from global and inter-ring bending of imperfect panel:
    Additional Nx in  base  of   ring,   dNx =  0.0000E+00
    Additional Nx at webtip of   ring,   dNx =  0.0000E+00
    Additional Nx in flange of   ring,   dNx =  0.0000E+00
 LABEL NO. IN STRUCT= 9560

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CHAPTER 25 Compute buckling load factors from PANDA-type
```

```
           theory for the various segments of a stringer and
           a ring. Typical buckling modes are displayed in
           Figs. 5 and 6 of Ref.[1B].

(lines skipped to save space)

Prebuck.resultant along stringer axis at root and tip of web:
  At root of web: -2.9376E+03;   At tip of web: -2.9376E+03

(lines skipped to save space)

Margin=  6.9253E-01  buckling margin stringer Iseg.3 . Local halfwaves=4  .MID.;FS=1.

(lines skipped to save space)

Margin=  2.5027E-01  buckling margin stringer Iseg.4 . Local halfwaves=4  .MID.;FS=1.

(lines skipped to save space)

Margin=  2.0179E-01  buckling stringer Isegs.3+4 together.M=4  ;C=0.     ;MID.;FS=1.4

(lines skipped to save space)

Margin=  8.7729E+00  buckling stringer Iseg 4 as beam on foundation. M=369;MID.;FS=1.2

(lines skipped to save space)

Prebuck.resultant along   ring   axis at root and tip of web:
  At root of web: -2.2922E+04;   At tip of web: -2.2922E+04
Knockdown factor to account for in-plane shearing of web and
  any anisotropic properties of the web, FKNOCK(6)=  8.3564E-01

(lines skipped to save space)

Margin=  1.4368E+00  buckling margin   ring   Iseg.3 . Local halfwaves=32 .MID.;FS=1.

(lines skipped to save space)

Margin=  1.0614E+01  buckling   ring   Iseg 4 as beam on foundation. M=67 ;MID.;FS=1.2

(lines skipped to save space)

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

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general buckling: smeared stiffeners, C11=  1.0238E+07, radius, R=  1.0000E+02

(lines skipped to save space)

EIGMNC=  2.72E+00  2.72E+00  3.79E+00  6.72E+00  1.00E+17  2.72E+00  1.00E+17
SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
MWAVEX=    1         1         2         4         0         1         1
NWAVEX=    3         3         3         5         0         3         0

(lines skipped to save space)

Buckling load factor before t.s.d.=  2.7174E+00 After t.s.d.=  2.4489E+00
```

```
(lines skipped to save space)

Number of circumferential halfwaves in buckling pattern=  3.0000E+00
Buckling load factor BEFORE knockdown for smeared stringers=  2.4489E+00
Buckling load factor AFTER  knockdown for smeared stringers=  2.2966E+00

General buckling load factor before and after knockdown:
EIGGEN(before modification by 5 factors below)     =  2.2966E+00
Knockdown factor from modal imperfection(s)        =  1.0000E+00
Knockdown factor for smearing rings on cyl. shell  =  9.0000E-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=  2.0669E+00

(lines skipped to save space)

    14      2.06690E+00   buckling load factor simp-support general buck;M=1;N=3;slope=0.
Margin=  8.7900E-01  buck.(SAND);simp-support general buck;M=1;N=3;slope=0.;FS=1.1

(lines skipped to save space)

Inter-ring buckling with smeared stringers and ring rolling
is not recorded as a margin because this type of buckling
has been superseded by the results from the discretized
inter-ring module model, for which inter-ring buckling
load factors have been computed in the range from n =     1
to n =   117 circumferential halfwaves.
The critical inter-ring-buckling-with-ring-rolling model has   20
circ. half waves, which lies within this range.

(lines skipped to save space)

Margin=  4.1833E-01  buck.(SAND);rolling only of stringers;M=8;N=0;slope=0.;FS=1.4

(lines skipped to save space)

Margin=  1.2841E+00  buck.(SAND);hiwave roll. of stringers;M=54;N=0;slope=0.;FS=1.2

(lines skipped to save space)

Ring rolling without participation of the panel skin
is not recorded as a margin because this type of buckling
has been superseded by the results from the discretized
"skin"-ring module model, for which buckling load factors
have been computed in the range from n =     1 to n =   117 circ. halfwaves.
The critical ring-rolling-without-participation-of-the-panel-skin model has    4
circ. half waves, which lies within this range.

(lines skipped to save space)

Margin=  6.1151E-01  buck.(SAND);rolling only axisym.rings;M=0;N=0;slope=0.;FS=1.4

(lines skipped to save space)

Margin=  6.9253E-01  buck.(SAND); STRINGERS:  web buckling;M=4;N=1;slope=0.;FS=1.

(lines skipped to save space)

Margin=  1.4222E+00  buck.(SAND);   RINGS:    web buckling;M=26;N=1;slope=0.;FS=1.

(lines skipped to save space)
```

```
 Margin=  6.9276E+02  (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.

 (lines skipped to save space)

 CHAPTER 27 Compute the objective function (e.g. WEIGHT).

****** BEGIN SUBROUTINE OBJECT (OBJECTIVE FUNCTION) ******

 Objective (weight of PANDA2 model of panel), OBJ =  1.1778E+04
****** END   SUBROUTINE OBJECT (OBJECTIVE FUNCTION) ******

-------- end of presentation of the abridged cylstif.OPM ----------------
-------- file for the optimized, perfect T-ring and T-stringer ----------
-------- stiffened cylindrical shell.                   -----------------
-------------------------------------------------------------------------
```

** PART 2.0: Processing with PANEL, PANEL2 and BIGBOSOR4 **

PART 2.1 Execute the PANDA2 processor called "PANEL" in order to produce a valid input file, cylstif.ALL, for BIGBOSOR4 for a prismatic model for LOCAL buckling

Next, get a plot from BIGBOSOR4 of buckling of the portion of the shell between rings from a BIGBOSOR4 model generated via the PANDA2 processor called PANEL. In this BIGBOSOR4 model the T-stringers are modeled as flexible shell segments and the T-rings are replaced by simple supports. The axial length of the prismatic shell included in the BIGBOSOR4 model is B(RNG), the ring spacing. Half of the circumference of the cylindrical shell is included in the model. The axial length of the model is 10.110 inches, which is the optimized ring spacing. The prismatic shell BIGBOSOR4 model is used.

bush-> panel

```
Please enter PANDA2 case name: cylstif


  ****************  PANEL  *******************

  The purpose of PANEL is to set up an input file, NAME.ALL,
  for a multi-module model of a panel. NAME is your name for
  the case. The file NAME.ALL is a BIGBOSOR4 input "deck" used
  by the batch run you launch next via the command BIGBOSORALL.
  ***********************************************

 Are you correcting, adding to, or using an existing file?=n
 n
 Do you want a tutorial session and tutorial output?=n
 n
 Panel length in the plane of the screen, L2=314.16
   314.1600
 Enter control (0 or 1) for stringers at panel edges=h

 0 means edge is half a stringer spacing away from nearest
   stringer;
```

```
1 means there is a stringer at each of the edges
  of the panel normal to the plane of the screen.

Enter control (0 or 1) for stringers at panel edges=1
        0
Enter control (1=sym; 2=s.s.) for boundary condition=h

1 means symmetry conditions applied at the edges of the
  panel normal to the plane of the screen;

2 means simple support conditions applied at the edges of the
  panel normal to the plane of the screen.

Enter control (1=sym; 2=s.s.) for boundary condition=2
        2
Enter ILOCAL=0 or 1 or -1 or -2 (Type (H)elp), ILOCAL=h

ILOCAL=0  (panel buckling) means that tangent stiffnesses will
be used for the wall stiffnesses.  The Nx, Ny, Nxy distributions
over the panel module cross section are those calculated in the
Koiter branch of PANDA2, that is, Nx, Ny, Nxy are for the locally
postbuckled panel. You will generally select NWAVE=1 axial
halfwaves when you are asked to supply a value for NWAVE. The
axial length of the shell is the length between adjacent rings.

ILOCAL = 1 (local buckling) means that original stiffnesses will
be used for the wall stiffnesses of the various segments in the
panel module. The Nx, Ny, Nxy distributions over the panel module
cross section are those calculated from SUBROUTINE FORCEX, that
is, Nx, Ny, Nxy are for the panel with no local buckling. You
will generally select NWAVE = number of axial halfwaves that
corresponds to the minimum local buckling load factor, EIGOLD,
computed by PANDA2. (See the *.OPM file). The axial length of the
shell is the length between adjacent rings.

ILOCAL = -1 (general buckling) The original stiffnesses are used
for the shell skin with smeared rings [CY(i,j,5)]. The tangent
stiffnesses are used for the stringer segments. The axial length
of the shell model is the total length of the shell multiplied by
the axial length modifier, LENMOD. Rings are smeared in this model.

ILOCAL = -2 (general buckling) The original stiffnesses are used
for the shell skin with all stiffeners smeared [CS(i,j)]. The
axial length of the shell model is the total length of the shell
multiplied by the axial length modifier, LENMOD.

Enter ILOCAL=0 or 1 or -1 or -2 (Type (H)elp), ILOCAL=1
        1
Number of halfwaves in the axial direction [see H(elp)],NWAVE=h

For general instability, NWAVE is usually equal to 1.

For a value you might use, inspect the NAME.OPM file. In the
list of buckling margins you will find the number of axial
halfwaves predicted via PANDA2 for various kinds of buckling.

You can use PANEL/BOSORALL to check the PANDA2 results via
BOSOR4 for general and/or local buckling, and for buckling
of the stiffener parts, and for stiffener rolling. Please note
that:
 1. BOSOR4 does not account for shear loading in its predictions
    of buckling, so that PANDA2 and BOSOR4 results will agree
    only if there is no applied in-plane shear loading.
```

```
  2. BOSOR4 does not account for the transverse shear deformation
     effect.

 Number of halfwaves in the axial direction [see H(elp)],NWAVE=1
        1
 How many eigenvalues (get at least 3) do you want?=3
        3


 DESCRIPTION OF FILES GENERATED BY THIS CASE:

 cylstif.ALL = Input data for BIGBOSOR4-type of preprocessor.
          correponding to discretized entire panel.
 cylstif.CBL = Contains part of cylstif data base.

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

 Next, give the command BIGBOSOR4LOG followed by BIGBOSORALL.

 BIGBOSOR4 to be used to find buckling of the panel with
 all stringer parts modelled as flexible shell segments. The
 buckling load factors from this rather elaborate model should
 be compared with those calculated from PANDA2


 (The input for PANEL is saved in the file, cylstif.PAN. The
  cylstif.PAN file is as follows:)
  -------- cylstif.PAN file: input for PANEL ----------------
      n         $ Do you want a tutorial session and tutorial output?
   314.1600     $ Panel length in the plane of the screen, L2
        0       $ Enter control (0 or 1) for stringers at panel edges
        2       $ Enter control (1=sym; 2=s.s.) for boundary condition
        1       $ Enter ILOCAL=0 or 1 or -1 or -2 (Type (H)elp), ILOCAL
        1       $ Number of halfwaves in the axial direction [see H(elp)],NWAVE
        3       $ How many eigenvalues (get at least 3) do you want?
----------- end of cylstif.PAN file for PANEL ---------------


The valid input file for BIGBOSOR4, cylstif.ALL, now exists:

-rw-r--r--  1 bush bush 167939 Feb 22 11:16 cylstif.ALL

This is a long file and is not listed here to save space.


-----------------------------------------------------------------------
```

**PART 2.2 Execute BIGBOSOR4 using the file, cylstif.ALL, as input,
in this particular run a prismatic model for LOCAL buckling**

Next, we must run BIGBOSOR4. We copy the file, cylstif.ALL,
to another working directory and execute BIGBOSOR4 there.

cd (to new working directory)
cp ../(old working directory)/cylstif.ALL .

bush-> bigbosor4log

```
BIGBOSOR4 COMMANDS HAVE BEEN ACTIVATED.

The BIGBOSOR4 commands, in the general order in which
you would probably use them, are:

help4           (get information on BOSOR4.)
input           (you provide segment-by-seg. input)
assemble        (concatenates segment data files)
bigbosorall     (batch run of pre, main, post proc.)
bosorplot       (batch run for generating plot files)
resetup         (input for restart run, same model)
bigrestart              (batch run of main & postprocessors)
cleanup         (delete all except for .DOC file)
getsegs         (generate segment files from .DOC)
modify          (modify a segment file)

Please consult the following sources for more
information about BOSOR4:

1.  help4 file  (type help4)
2.  bosor4.story        (good idea to print this file)
3.  bosor4.news (news of BOSOR4 updates)
4.  Documents listed under HELP4 OVERVIEW DOC
```

bush-> bigbosorall

```
Enter case name: cylstif
B (background), F (foreground), or Q (NQS - network queue system): f

Running BIGBOSOR4: bigbosorall, case: cylstif

Executing bigbosorall
Normal termination: bigbosorall
Job finished.
Inspect the output file cylstif.OUT

Menu: bosorplot, resetup, cleanup, getsegs, modify, input, help4
```

PART 2.3 Inspect the cylstif.OUT file

Inspect the cylstif.OUT file. Search for the string,
"EIGENVALUE(", including the trailing parenthesis.
You will find the following list output there:

```
---------- from the cylstif.OUT file ---------------
 BUCKLING LOADS FOLLOW
 AXIAL HALF WAVE NUMBER, N =       1

 EIGENVALUES =
    1.21180E+00    1.21651E+00    1.22461E+00

 **** CRITICAL EIGENVALUE AND WAVENUMBER ****
 EIGCRT=  1.2118E+00; NO. OF AXIAL HALF WAVES, NWVCRT=    1
 ****************************************************

 ***** EIGENVALUES AND MODE SHAPES *****
  EIGENVALUE(AXIAL HALF WAVES)
 =======================================
    1.2118E+00(     1)
 =======================================
```

----------end of "from the cylstif.OUT file" ------------

PART 2.4 Compare predictions from BIGBOSOR4 with those from PANDA2 that are listed in PART 1.19, CHAPTER 14 (LOCAL buckling)

Compare with the eigenvalue from CHAPTER 14 of the PANDA2 file, cylstif.OPM, for the perfect shell:

```
 BUCKLING LOAD FACTORS FROM BOSOR4-TYPE DISCRETIZED MODEL...
          (skin-stringer discretized module of local buckling)
  AXIAL     BUCKLING        KNOCKDOWN FOR    KNOCKDOWN FOR      BUCKLING
  HALF-    LOAD FACTOR     TRANSVERSE SHEAR  IN-PLANE SHEAR    LOAD FACTOR
  WAVES  BEFORE KNOCKDOWN    DEFORMATION     LOADING AND/OR  AFTER KNOCKDOWN
                                               ANISOTROPY
    M        EIGOLD              KSTAR           KNOCK     EIGOLD*KSTAR*KNOCK
    1      1.21563E+00       9.83375E-01      1.00000E+00     1.19542E+00
```

PART 2.5 Execute the BIGBOSOR4 processor called "bosorplot" in order to get a plot of the critical LOCAL buckling mode

Get a plot of the buckling mode:

bush-> bosorplot

```
Please enter the BIGBOSOR4 case name: cylstif

Do you want to use Xgraph or create a PostScript file? (Choose X or P) p

One, maybe Two moments please...

Text file(s) have been created containing plot data.  The names of the
files explain to a greater or lesser extent what the data represent.
Some plot files contain data for more than one plot.
1)      cylstif..R,Z_EIGENMODE_1--N_1
2)      cylstif..R,Z_EIGENMODE_2--N_1
3)      cylstif..R,Z_EIGENMODE_3--N_1
4)      cylstif..R,Z_RingLocation
CR)     to QUIT
Please choose the number of the file you wish to plot: 1
Plotting: Undeformed & Deformed Axial Station as a function of Radius

The PostScript file, metafile.ps, has been created.
Please choose one of the three options below:

   1) Rename the PostScript file.  This is useful if
      you don't have access to a PostScript printer on your
      machine, but you wish to save to a file so you can later
      transfer it to a different machine for printing.

         Example:  mv metafile.ps plot1.ps

   2) Enter an "lpr" command.  This is useful if your default
      printer is not PostScript, but there is a PostScript
      printer available on your system.

         Example:  lpr -PApplelaser metafile.ps
```

```
   3) Press the return key.  This executes the command:

                    lpr metafile.ps

      This assumes that your default printer is a PostScript
      printer.

Enter your command> <enter>
Printing PostScript plot on the default printer...

Text file(s) have been created containing plot data.  The names of the
files explain to a greater or lesser extent what the data represent.
Some plot files contain data for more than one plot.
1)      cylstif..R,Z_EIGENMODE_1--N_1
2)      cylstif..R,Z_EIGENMODE_2--N_1
3)      cylstif..R,Z_EIGENMODE_3--N_1
4)      cylstif..R,Z_RingLocation
CR)     to QUIT
Please choose the number of the file you wish to plot: <enter>

----------- end of obtaining the plot file, metafile.ps --------------
```

bush-> cp metafile.ps plot1.ps
bush-> gv plot1.ps

```
 ("gv" means "ghost view": you will see the buckling mode
  on your screen. Take a "screen shot" of this buckling mode
  and store it in the file, 3.cylstif.localbuck.panel.png)


-----------------------------------------------------------------------
```

PART 2.6 Execute the PANDA2 processor called "PANEL" and the BIGBOSOR4 processors, bigbosorall and bosorplot, in order to obtain a plot of the critical GENERAL buckling mode and load factor (eigenvalue)

```
Next, get a plot from BIGBOSOR4 of buckling of the entire
shell from a BIGBOSOR4 model generated via the PANDA2
processor called PANEL. In this BOSOR4 model the T-rings
are smeared out and the T-stringers are modeled as flexible shell
segments. 180 degrees of the cylindrical shell are included
in the model. The axial length of the model is 300 inches.
The prismatic shell BIGBOSOR4 model is used.
```

bush-> panel

```
Please enter PANDA2 case name: cylstif

The correct input for the PANEL processor follows:

---- input, cylstif.PAN, for PANEL for general buckling model -----
--------------- to be analyzed with BIGBOSOR4 ---------------------

      n         $ Do you want a tutorial session and tutorial output?
   314.1600     $ Panel length in the plane of the screen, L2
         0      $ Enter control (0 or 1) for stringers at panel edges
         2      $ Enter control (1=sym; 2=s.s.) for boundary condition
        -1      $ Enter ILOCAL=0 or 1 or -1 or -2 (Type (H)elp), ILOCAL
         1      $ Number of halfwaves in the axial direction [see H(elp)],NWAVE
         3      $ How many eigenvalues (get at least 3) do you want?
```

------------ end of cylstif.PAN file for general buckling model -------

The valid input file for BIGBOSOR4, cylstif.ALL, now exists:

-rw-r--r-- 1 bush bush 167939 Feb 22 11:45 cylstif.ALL

This is a long file and is not listed here to save space.

Next, we must run BIGBOSOR4. We copy the file, cylstif.ALL,
to another working directory and execute BIGBOSOR4 there.

cd (to new working directory)
cp ../(old working directory)/cylstif.ALL .

bush-> bigbosor4log

bush-> bigbosorall

```
Enter case name: cylstif
B (background), F (foreground), or Q (NQS - network queue system): f

Running BIGBOSOR4: bigbosorall, case: cylstif

Executing bigbosorall
Normal termination: bigbosorall
Job finished.
Inspect the output file cylstif.OUT

Menu: bosorplot, resetup, cleanup, getsegs, modify, input, help4
```

Inspect the cylstif.OUT file. Search for the string,
"EIGENVALUE(", including the trailing parenthesis.
You will find the following list output there:

```
---------- from the cylstif.OUT file ---------------
 BUCKLING LOADS FOLLOW
 AXIAL HALF WAVE NUMBER, N =       1

 EIGENVALUES =
    2.88019E+00    3.62711E+00    4.75444E+00

 **** CRITICAL EIGENVALUE AND WAVENUMBER ****
 EIGCRT=  2.8802E+00; NO. OF AXIAL HALF WAVES, NWVCRT=    1
 ****************************************************

 ***** EIGENVALUES AND MODE SHAPES *****
  EIGENVALUE(AXIAL HALF WAVES)
 =======================================
    2.8802E+00(     1)
 =======================================
----------end of "from the cylstif.OUT file" ------------
```

Compare with the prediction from CHAPTER 26 of PART 1.19:

```
 general buckling: smeared stiffeners, C11=  1.0238E+07, radius, R=  1.0000E+02

 (lines skipped to save space)
```

```
 EIGMNC=  2.72E+00  2.72E+00  3.79E+00  6.72E+00  1.00E+17  2.72E+00  1.00E+17
 SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
 MWAVEX=     1         1         2         4         0         1         1
 NWAVEX=     3         3         3         5         0         3         0

 (lines skipped to save space)

 Buckling load factor before t.s.d.=  2.7174E+00 After t.s.d.=  2.4489E+00

 (lines skipped to save space)

 Number of circumferential halfwaves in buckling pattern=  3.0000E+00
 Buckling load factor BEFORE knockdown for smeared stringers=  2.4489E+00
 Buckling load factor AFTER  knockdown for smeared stringers=  2.2966E+00

 General buckling load factor before and after knockdown:
 EIGGEN(before modification by 5 factors below)     =  2.2966E+00
 Knockdown factor from modal imperfection(s)        =  1.0000E+00
 Knockdown factor for smearing rings on cyl. shell  =  9.0000E-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=  2.0669E+00
------------------------------------------------------------------------------
```

Get a plot of the general buckling mode:

bush-> bosorplot

Please enter the BIGBOSOR4 case name: cylstif

Do you want to use Xgraph or create a PostScript file? (Choose X or P) p

etc., etc. (as above)

----------- end of obtaining the plot file, metafile.ps --------------

bush-> cp metafile.ps plot2.ps
bush-> gv plot2.ps

 ("gv" means "ghost view": you will see the buckling mode
  on your screen. Take a "screen shot" of this buckling mode
  and store it in the file, 4.cylstif.genrlbuck.panel.png)

PART 2.7 Execute the PANDA2 processor called "PANEL2" and the BIGBOSOR4 processors, bigbosorall and bosorplot, in order to obtain plots of the critical RING SIDESWAY and INTER-RING buckling modes and load factors (eigenvalues) from BIGBOSOR4

Next, get plots from BIGBOSOR4 of buckling of the entire shell from a BIGBOSOR4 model generated via the PANDA2 processor called PANEL2. In this BOSOR4 model the T-stringers are smeared out and the T-rings are modeled as flexible shell segments. The shell is modeled as a cylindrical shell, not as a prismatic shell as is the case when the PANDA2 processor called PANEL is used.

bush-> panel2

```
Please enter PANDA2 case name: cylstif

The correct input for PANEL2 is as follows:

---------- input file, cylstif.PAN, for PANEL2 -------------
      n         $ Do you want a tutorial session and tutorial output?
       300      $ Length of the ring-stiffened cylindrical shell, L1
         1      $ Choose BOSOR4 model: INDIC=1 or INDIC=4; INDIC
  -25000.00     $ Axial resultant Nx in Load Set A, Nx
         0      $ Axial resultant Nxo in Load Set B, Nxo
  -500.0000     $ Normal pressure p
         1      $ IABP = 1 if pressure in Load Set A; IABP=0 otherwise. IABP
         2      $ Enter control (1=sym; 2=s.s.; 3=clamp) for buckling b.c.
         2      $ Starting number of circumferential waves [see H(elp)],N0B
        40      $ Ending number of circumferential waves [see H(elp)],NMAXB
         2      $ Increment in number of circumferential waves, INCRB
         1      $ Number of eigenvalues for each circ. wavenumber, NVEC
--------- end of the cylstif.PAN file for PANEL2 --------------


The valid input file for BIGBOSOR4, cylstif.ALL, now exists:

-rw-r--r--  1 bush bush 167939 Feb 22 11:45 cylstif.ALL

This is a long file and is not listed here to save space.

Next, we must run BIGBOSOR4. We copy the file, cylstif.ALL,
to another working directory and execute BIGBOSOR4 there.
```

cd (to new working directory)
cp ../(old working directory)/cylstif.ALL .

bush-> bigbosor4log

bush-> bigbosorall

```
Enter case name: cylstif
B (background), F (foreground), or Q (NQS - network queue system): f

Running BIGBOSOR4: bigbosorall, case: cylstif

Executing bigbosorall
Normal termination: bigbosorall
Job finished.
Inspect the output file cylstif.OUT

Menu: bosorplot, resetup, cleanup, getsegs, modify, input, help4


Inspect the cylstif.OUT file. Search for the string,
"EIGENVALUE(", including the trailing parenthesis.
You will find the following list output there:

------- begin part of the cylstif.OUT file ------------
 JUST LEFT SUBROUTINE OUT2

 **** CRITICAL EIGENVALUE AND WAVENUMBER ****
 EIGCRT=  1.6141E+00; NO. OF CIRC. WAVES, NWVCRT=    4
 ***************************************************
```

```
 ***** EIGENVALUES AND MODE SHAPES *****
  EIGENVALUE(CIRC. WAVES)
 =======================================
    1.6929E+00(     2)
    1.6141E+00(     4) <--ring sidesway critical mode
    1.8127E+00(     6)    (Compare with PANDA2, CHAPTERs 22 & 26
    2.2312E+00(     8)     of Part 1.19)
    2.7896E+00(    10)
    3.3854E+00(    12)
    3.8828E+00(    14)
    3.8381E+00(    16)
    3.3807E+00(    18)
    3.0163E+00(    20)
    2.7499E+00(    22)
    2.5632E+00(    24)
    2.4399E+00(    26)
    2.3680E+00(    28)
    2.3381E+00(    30) <--inter-ring critical mode
    2.3432E+00(    32)    (Compare with PANDA2, CHAPTER 22
    2.3782E+00(    34)     of Part 1.19)
    2.4388E+00(    36)
    2.5220E+00(    38)
    2.6253E+00(    40)
 =======================================
------------- end of part of cylstif.OUT file ------------

Compare with the prediction from PANDA2 listed in
CHAPTER 22 of PART 1.19:

From CHAPTER 22 of PART 1.19, inter-ring buckling mode:

 BUCKLING LOAD FACTORS FROM BOSOR4-TYPE DISCRETIZED MODEL...
          (skin-smeared-stringer-ring discretized module)
  HOOP      BUCKLING        KNOCKDOWN FOR    KNOCKDOWN FOR      BUCKLING
  HALF-    LOAD FACTOR     TRANSVERSE SHEAR  IN-PLANE SHEAR    LOAD FACTOR
  WAVES  BEFORE KNOCKDOWN    DEFORMATION     LOADING AND/OR  AFTER KNOCKDOWN
                                               ANISOTROPY
    n        EIGOLD             KSTAR            KNOCK     EIGOLD*KSTAR*KNOCK
   32      2.44726E+00       1.00000E+00      1.00000E+00     2.44726E+00
   35      2.48779E+00       1.00000E+00      1.00000E+00     2.48779E+00
   29      2.47892E+00       1.00000E+00      1.00000E+00     2.47892E+00
 Buckling load factor before t.s.d.=  2.4473E+00 After t.s.d.=  2.2273E+00

 (lines skipped to save space)

 knockdown for smeared stringers from SUB.EIGMOD,
                                         SMRFAC=  5.4900E-01
 knockdown for transverse shear deformation (t.s.d.) from SUB.SHRRED,
                                         SHRFAC=  9.1013E-01
 Buckling load factor BEFORE knockdown for smeared stringers=  2.2273E+00
 Buckling load factor AFTER  knockdown for smeared stringers=  1.2228E+00
 (lines skipped to save space)
 Margin=  1.1164E-01  Inter-ring bucklng, discrete model, n=32  circ.halfwaves;FS=1.1

 (lines skipped to save space)


From CHAPTER 22 of PART 1.19, ring sidesway buckling mode:

 Margin=  5.8244E-01  Lo-n Ring sidesway, discrete model, n=4   circ.halfwaves;FS=1.1

The ring sidesway buckling load factor can be obtained from
the Margin as follows:
```

```
(buckling load factor) = (factor of safety) x (Margin + 1.0)
(buckling load factor) = (1.1) x (0.58244 + 1.0) = 1.74068
```

Get plots of the two "critical" buckling modes:

```
bush-> bosorplot
Please enter the BIGBOSOR4 case name: cylstif

Do you want to use Xgraph or create a PostScript file? (Choose X or P) p

etc., etc. (as above)

----------- end of obtaining the plot file, metafile.ps --------------
```

bush-> cp metafile.ps plot4.ps
bush-> gv plot4.ps

("gv" means "ghost view": you will see the buckling mode on your screen. Take a "screen shot" of this buckling mode and store it in the file, 5.cylstif.ringsidesway.panel2.png)

bush-> bosorplot

```
Please enter the BIGBOSOR case name: cylstif

Do you want to use Xgraph or create a PostScript file? (Choose X or P) p

etc., etc. (as above)

----------- end of obtaining the plot file, metafile.ps --------------
```

bush-> cp metafile.ps plot30.ps
bush-> gv plot30.ps

("gv" means "ghost view": you will see the buckling mode on your screen. Take a "screen shot" of this buckling mode and store it in the file, 6.cylstif.interring.panel2.png)

****

PART 3.0: Processing with CHANGE, STAGSUNIT, and STAGS

****

PART 3.1 Edit the file, cylstif.CHG, (See PART 1.15) in order to create dimensions that are "STAGS-worthy" (integral numbers of stringer spacings & ring spacings over the circumference and length of the cylindrical shell)

Next, we wish to set up STAGS models of the optimized T-ring and T-stringer stiffened cylindrical shell. First, we must use the PANDA2 processor, CHANGE, to make sure that there are an integral number of stringers over 360 degrees of circumference and an integral number of rings over the

300-inch length. Accordingly, we do the following:

We first edit the file, cylstif,CHG, changing the optimized values of
B(STR) = 10.110,   B2(STR) = 3.3697, and B(RNG) = 31.85 inches to
B(STR) = 10.13417, B2(STR) = 3.3777, and B(RNG) = 33.3333. With
B(STR) = 10.13417 inches there are exactly 62 stringers over 360
degrees of circumference, and with B(RNG) = 33.3333 inches there
are exactly 9 ring spacings over the length, 300 inches. The new
cylstif.CHG file follows:

```
------------- cylstif.CHG file for "STAGS-worthy" shell ----------------
      n          $ Do you want a tutorial session and tutorial output?
      y          $ Do you want to change any values in Parameter Set No. 1?
         1       $ Number of parameter to change (1, 2, 3, . .)
   10.13417      $ New value of the parameter
      y          $ Want to change any other parameters in this set?
         2       $ Number of parameter to change (1, 2, 3, . .)
   3.377856      $ New value of the parameter
      y          $ Want to change any other parameters in this set?
         3       $ Number of parameter to change (1, 2, 3, . .)
   7.816700      $ New value of the parameter
      y          $ Want to change any other parameters in this set?
         4       $ Number of parameter to change (1, 2, 3, . .)
   2.534000      $ New value of the parameter
      y          $ Want to change any other parameters in this set?
         5       $ Number of parameter to change (1, 2, 3, . .)
  0.7689600      $ New value of the parameter
      y          $ Want to change any other parameters in this set?
         6       $ Number of parameter to change (1, 2, 3, . .)
  0.2038000      $ New value of the parameter
      y          $ Want to change any other parameters in this set?
         7       $ Number of parameter to change (1, 2, 3, . .)
  0.8449600E-01  $ New value of the parameter
      y          $ Want to change any other parameters in this set?
         8       $ Number of parameter to change (1, 2, 3, . .)
   33.33333      $ New value of the parameter
      y          $ Want to change any other parameters in this set?
        10       $ Number of parameter to change (1, 2, 3, . .)
   9.783000      $ New value of the parameter
      y          $ Want to change any other parameters in this set?
        11       $ Number of parameter to change (1, 2, 3, . .)
   4.303700      $ New value of the parameter
      y          $ Want to change any other parameters in this set?
        12       $ Number of parameter to change (1, 2, 3, . .)
  0.5672900      $ New value of the parameter
      y          $ Want to change any other parameters in this set?
        13       $ Number of parameter to change (1, 2, 3, . .)
  0.9452400      $ New value of the parameter
      n          $ Want to change any other parameters in this set?
      n          $ Do you want to change values of "fixed" parameters?
      n          $ Do you want to change values of allowables?
---------------- end of the "STAGS-worthy" cylstif.CHG file --------------
```

PART 3.2 Execute the PANDA2 processors called "CHANGE" and "SETUP"

Next, we execute CHANGE and SETUP:

bush-> change
Please enter PANDA2 case name: cylstif

```
 ******************   CHANGE   *******************

 You use CHANGE to change parameters without having to go back
 to BEGIN. The parameters you can change are segregated into
 three groups:

    1. parameters elegible to be decision variables
    2. parameters not elegible to be decision variables
    3. allowables (for example, max. strain).

 Your interactive input is saved on a file called cylstif.CHG, in
 which cylstif is the same name you used for BEGIN, SETUP, etc.
 A summary of the output from CHANGE is stored in cylstif.OPC.

 ************************************************************

 Are you correcting, adding to, or using an existing file?=y

 (The interactive "CHANGE" session zips by on your screen)
```

bush-> setup

```
Enter case name: cylstif

 (The output from SETUP zips by on your screen)

Next give the command: DECIDE or MAINSETUP.
```

PART 3.3 Execute the PANDA2 processors called "MAINSETUP" and "PANDAOPT"

bush-> mainsetup

```
Please enter PANDA2 case name: cylstif


  *****************   MAINSETUP   ****************
 The purpose of this processor is to permit you to choose loads
 and initial imperfections, Nx, Ny, Nxy, Mx, My, Nxo, Nyo, p,
 T(iseg), Wimp(global), Wimp(local),  (up to 5 sets of them);
 safety factors for general instability, panel instability,
 local instability (panel skin), local instability (stiffener
 parts), and stress; and strategy parameters for subsequent
 batch execution of an optimization analysis (analysis type 1);
 or an analysis of a fixed design at fixed load levels
 (analysis type 2); or an analysis of a fixed design for a
 single load set for monotonically increasing load levels
 (test simulation: analysis type 3).

 Results of the interactive session in MAINSETUP are saved on a
 file called cylstif.OPT, which will appear at the beginning of
 the cylstif.OPM file when the mainprocessor batch run launched
 by your command PANDAOPT has been completed.

 NOTE: JUST HIT "RETURN" FOR DEFAULT VALUE OF INPUT DATUM. IF
   PANDA2 REQUIRES AN INPUT, IT WILL SAY "PLEASE SAY SOMETHING"
  ***************************************************


 Are you correcting, adding to, or using an existing file?=y
```

```
 (The interactive "MAINSETUP" session zips by on your screen)

 Next, give the command CHOOSETEMP or PANDAOPT or SUPEROPT.
```

bush-> pandaopt

```
The purpose of PANDAOPT is to launch the batch run which performs
optimization or buckling according to the strategy parameters
established the last time you did a MAINSETUP. Output from PANDAOPT
is stored in a file called casename.OPM, in which casename is
the name of the case. You will want to examine casename.OPM as soon
as PANDAOPT is finished.

Enter case name: cylstif
B (background), F (foreground), or Q (NQS - network queue system): f

Running PANDA2: pandaopt, case: cylstif

Executing main
Normal termination: main
still processing... Please wait.
Executing store
Normal termination: store
still processing... Please wait.
cylstif mainprocessor run completed successfully.
Menu: PANDAOPT, CHOOSEPLOT, MAINSETUP, CHANGE
Please examine the files: cylstif.OPM, cylstif.OPP, and cylstif.OPI
If ITYPE=1, print the file called cylstif.OPP
If ITYPE=3 or 4, print the file called cylstif.OPI
Run PANDAOPT several times for optimization.


----------------------------------------------------------------------
```

PART 3.4 Inspect the cylstif.OPM file

```
  (Inspect the new cylstif.OPM file. The new design
   margins are not much different from those listed
   above for the perfect shell:)

 MARGINS FOR CURRENT DESIGN: LOAD CASE NO. 1, SUBCASE NO. 1
 MAR. MARGIN
 NO.  VALUE                DEFINITION
 1   5.98E-02 Local buckling from discrete model-1.,M=1   axial halfwaves;FS=1.1
 2   5.98E-02 Bending-torsion buckling; M=1  ;FS=1.1
 3   2.64E-01 eff.stress:matl=1,SKN,Dseg=2,node=6,layer=1,z=0.3845; MID.;FS=1.
 4   7.66E-02 (m=1   lateral-torsional buckling load factor)/(FS)-1;FS=1.1
 5   5.41E-02 Inter-ring bucklng, discrete model, n=29  circ.halfwaves;FS=1.1
 6   5.64E-01 Lo-n Ring sidesway, discrete model, n=4   circ.halfwaves;FS=1.1
 7   2.64E-01 eff.stress:matl=1,SKN,Iseg=2,at:n=6,layer=1,z=0.3845;-MID.;FS=1.
 8   7.13E-01 buckling margin stringer Iseg.3 . Local halfwaves=4  .MID.;FS=1.
 9   2.55E-01 buckling margin stringer Iseg.4 . Local halfwaves=4  .MID.;FS=1.
10   2.16E-01 buckling stringer Isegs.3+4 together.M=4  ;C=0.     ;MID.;FS=1.4
11   8.85E+00 buckling stringer Iseg 4 as beam on foundation. M=369;MID.;FS=1.2
12   1.41E+00 buckling margin   ring   Iseg.3 . Local halfwaves=32 .MID.;FS=1.
13   1.05E+01 buckling   ring   Iseg 4 as beam on foundation. M=67 ;MID.;FS=1.2
14   8.24E-01 buck.(SAND);simp-support general buck;M=1;N=3;slope=0.;FS=1.1
15   1.69E+01 buck.(SAND);rolling with smear rings; M=93;N=1;slope=0.;FS=1.1
16   4.30E-01 buck.(SAND);rolling only of stringers;M=8;N=0;slope=0.;FS=1.4
17   1.30E+00 buck.(SAND);hiwave roll. of stringers;M=54;N=0;slope=0.;FS=1.2
18   5.92E-01 buck.(SAND);rolling only axisym.rings;M=0;N=0;slope=0.;FS=1.4
19   7.13E-01 buck.(SAND); STRINGERS:  web buckling;M=4;N=1;slope=0.;FS=1.
20   1.39E+00 buck.(SAND);   RINGS:    web buckling;M=26;N=1;slope=0.;FS=1.
```

```
21  6.99E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
```

PART 3.5 Execute the PANDA2 processor called "STAGSUNIT" in order to generate valed input files *.bin & *.inp for STAGS. In this first STAGSUNIT case we include the entire cylindrical shell in the STAGS model with the T-rings and T-stringers all modeled with flexible shell segments (Shell units in STAGS jargon).

Next, in order to generate the STAGS model, execute the PANDA2 processor called STAGSUNIT:

bush-> stagsunit

```
Please enter PANDA2 case name: cylstif


  ****************  STAGSUNIT *******************

  The purpose of STAGSUNIT is to produce input files,

            NAME.inp,  NAME.bin  and  NAME.ppn

  for a multi-module model of a panel. NAME is your name for
  the case. The files NAME.inp, NAME.bin can be used as input
  for the  STAGS  computer program.  STAGS is a general finite
  element code for the nonlinear static and dynamic analysis
  of stiffened shell structures.  You should use STAGS to
  check the load-carrying capacity of the panels you designed
  with PANDA2. The file NAME.ppn can be used directly as input
  for the STAGS postprocessor, POSTP.  STAGSUNIT also creates
  a file called NAME.STG, which can be used as input for
  future runs of STAGSUNIT.
  ***********************************************

 Are you correcting, adding to, or using an existing file?=n
 n
 Do you want a tutorial session and tutorial output?=n
 n
 Choose type of STAGS analysis (1,3,4,5,6),INDIC=h

 INDIC = 1 means linear bifurcation buckling analysis. The
           purposes are:
           (a) to compare with PANDA2 predictions for local
               and/or general buckling load factors and mode shapes;
           (b) to obtain one or more buckling mode shapes to be
               used later with an INDIC = 3 nonlinear analysis
               of an imperfect shell.
               The imperfections are in the shapes of user-selected
               buckling modes predicted with the INDIC=1 analysis.

 INDIC = 3 means nonlinear static analysis over a user-provided
           range of loads, analogous to the ITYPE=3 analysis
           (test simulation) with PANDA2.

 The user should first run STAGSMODEL or STAGSUNIT with INDIC = 1,
 followed by subsequent runs of STAGSMODEL or STAGSUNIT with INDIC = 3.
 If STAGS cannot continue to obtain solutions for load factors that
 approach the general instability or wide-column buckling load predicted
 by PANDA, then it will be necessary to use a more complex strategy
```

```
involving the other analysis types, INDIC = 4, 5, and 6:

INDIC = 4 means bifurcation buckling with nonlinear prebuckling.
        To be used if the user wants a new imperfection shape.

INDIC = 5 means small vibrations with nonlinear prebuckling.
        To be used in order to get appropriate time step for
        nonlinear transient analyses.

INDIC = 6 means nonlinear transient response analysis. (see
        PANDA2.NEWS ITEM 259 and AIAA Paper No. 97-1141).

Choose type of STAGS analysis (1,3,4,5,6),INDIC=1
        1
Restart from ISTARTth load step (0=1st nonlinear soln), ISTART=h

If this is NOT a STAGS POSTPROCESSOR run:
  ISTART = 0 Always use ISTART = 0 if INDIC = 1
  ISTART = 0 means you are starting the nonlinear analysis and
             have no previous load steps to start from.
  ISTART > 0 means you are using the solution at load step
             number ISTART as a starting solution for the next
             STAGS run.  If ISTART > 0 make sure that the starting
             load factors STLD(1) and STLD(2) on the C-1 record
             correspond to load step ISTART.

If this IS a STAGS POSTPROCESSOR run:
  ISTART = n is the load step number for which you want to
             generate data via the STAGS postprocessor POSTP.
             n = 0 means you will get the linear response.

Restart from ISTARTth load step (0=1st nonlinear soln), ISTART=0
        0
Local buckling load factor from PANDA2, EIGLOC=h

Use EIGLOC = 0 unless INDIC = 1  (bifurcation buckling).

You can find EIGLOC in the NAME.OPM file. Look for the margin
or margins corresponding to local buckling. The load factor
for local buckling is given by:

           EIGLOC = FSLOC*(MARGIN + 1.)

in which FSLOC is the factor of safety for local buckling.

Local buckling load factor from PANDA2, EIGLOC=1.155
  1.155000
Are the dimensions in this case in inches?=y
y
Nonlinear (0) or linear (1) kinematic relations?, ILIN=h

Ordinarily, you should set ILIN = 0

However, occasionally general buckling mode shapes are
"dirty". That is, smooth relatively long-wavelength general
buckling modes are "polluted" by very short-wavelength
"noise". Example: see Fig. 39, p 1612 of "Optimization of perfect
and imperfect ring and stringer stiffened cylindrical shells
with PANDA2 and evaluation of the optimum designs with STAGS",
AIAA Paper 2002-1408, Proceedings of the AIAA 43rd SDM
Conference, Denver, CO, 2002, pp 1562-1613.

With ILIN = 1 much, perhaps all, of the short-wavelength
"noise" will be filtered out. Try ILIN = 0 first. If you get
```

```
"polluted" general buckling mode shapes which are usually
unsuitable to use as initial imperfection shapes, use
ILIN = 1 for the linear bifurcation buckling analysis.

NOTE: For the nonlinear (INDIC=3) STAGS runs, always use
ILIN = 0

Nonlinear (0) or linear (1) kinematic relations?, ILIN=0
        0
Type 1 for closed (360-deg) cyl. shell, 0 otherwise, ITOTAL=h

If you are modeling a cylindrical shell that spans 360
degrees, answer ITOTAL = 1

If you are modeling a flat or cylindrical panel that spans
less than 360 degrees then answer ITOTAL = 0 except in the
following circumstance:

If you are setting up a compound cylindrical model and the
compound model spans 360 degrees, answer ITOTAL = 1.

See Fig. 56 in the paper, "Difficulties in optimization of
imperfect stiffened cylindrical shells", AIAA Paper 2006-1943,
47th AIAA SDM Meeting, Newport, RI May 1-4, 2006, for an
example of a "compound" model. If the compound model is a
complete (360-degree) cylindrical shell it is closed (ITOTAL=1).
The logic will proceed as if the shell is closed even though
you set YSTAGS to a value considerably less than that which
corresponds to 360 degrees.

Type 1 for closed (360-deg) cyl. shell, 0 otherwise, ITOTAL=1
        1
X-direction length of the STAGS model of the panel: XSTAGS=h

This is the axial length of the part of the panel to be included
in the STAGS model. (The X-direction is along the stringer axis).

If PANDA2 indicates that there are many axial waves in the local
buckling pattern, then it may be best to use STAGS to explore only
the local bifurcation and post-bifurcation behavior, rather than
the general instability behavior. In such a case you might choose
a length XSTAGS that is equal to no more than about 10 axial
half-waves of the local buckling pattern.

X-direction length of the STAGS model of the panel: XSTAGS=300.
      300
Panel length in the plane of the screen, L2=h

For a cylindrical panel, this is the arc length along the
circumference of the entire panel.  A complete cylindrical
shell can be modelled by using  L2 = pi*radius. Then the number
of half-waves over this circumferential length is the same as
the number of full waves around the complete 360 degree circum-
ference.  If you are analyzing a complete cylindrical shell,
especially one with loads that vary around the circumference,
it will probably be best to divide it into panels. Then analyze
the panel as a structure subjected to multiple sets of uniform
loads.  (See the paper, PANDA2--program for minimum weight
design of stiffened, composite, locally buckled panels, for an
example. Computers and Structures, Vol. 25, pp 570-574, Fig. 79)

Panel length in the plane of the screen, L2=628.31854
  628.3185
STAGSUNIT MAY HAVE CHANGED YOUR INPUT VALUE OF YSTAGS:
```

```
YOUR INPUT VALUE OF ARC LENGTH OF THE PANEL, YSTAGS=  6.2832E+02
STAGSUNIT HAS CHANGED THE ARC LENGTH TO      YSTAGS=  6.2832E+02
WHICH IS EXACTLY EQUAL TO A MULTIPLE OF THE STRINGER SPACING.
Is the nodal point spacing uniform along the stringer axis?=h

Generally answer Y. If you have a panel in which bending
is significant, and if PANDA2 predicts many axial halfwaves
in the local buckling pattern, (more than 10, for example),
then you might answer N. You will then be asked further
questions about the distribution of nodal points in the axial
direction, x.

If local buckling occurs only near the midlength of the
panel (because of bending under pressure, for example)
then you might want to concentrate nodal points in that region.
If local buckling might occur both near the midlength of the
panel and near the ends (bending of a clamped panel under
pressure, for example) then you might want to concentrate
nodal points near the midlength and near one or both ends
of the panel.

Is the nodal point spacing uniform along the stringer axis?=y
y
Number of nodes in the X-direction: NODEX=h

NODEX must be an odd integer. It may be changed later.
The X-direction is the direction along the stringer axis.
You should have at least three nodes per axial halfwave of
the local buckling pattern.

This input datum is not used if there are rings.

Number of nodes in the X-direction: NODEX=51
       51
Number of nodes in the Y-direction: NODEY=h

NODEY must be an odd integer. It may be changed later.
The Y-direction is the direction around the circumference.
You should have at least three nodes per circumferential
halfwave of the general or inter-ring buckling pattern.

This input datum is not used if there are stringers that
are not to be smeared out.

Number of nodes in the Y-direction: NODEY=101
      101

You will next be asked to provide loads for Load Set A
(Nx, Ny, Nxy, p) followed by loads for Load Set B (Nx0, Ny0, p0)
for the STAGS finite element model.

Now provide loads (Nx, Ny, Nxy, p) for Load Set A.

Resultant (e.g. lb/in) normal to the plane of screen, Nx=h

What is wanted is the applied line load in the L1 (axial)
direction in units of force/length. Negative for compression.
If this axial load varies in the L2 (circumferential) direction,
use the largest compressive value applied to that edge of the
panel.

What is wanted now is the axial load in Load Set A, that is
the eigenvalue load: the load to be multiplied by the critical
load factor (the eigenvalue) in computations of the critical
```

```
applied load.

Resultant (e.g. lb/in) normal to the plane of screen, Nx=-25000.
 -25000.00
Resultant (e.g. lb/in) in the plane of the screen,    Ny=-50000.
 -50000.00
In-plane shear in load set A,                  Nxy=0.
  0.000000
Normal pressure in STAGS model in Load Set A, p=h

If the panel is curved, the normal pressure p must be
consistent with the applied hoop resultant Ny:
p*r = Ny, in which r = cylindrical shell radius.
(r is always positive).

Normal pressure in STAGS model in Load Set A, p=h
 There is no more help. Do your best.
Normal pressure in STAGS model in Load Set A, p=-500.
 -500.0000

Next, provide loads for Load Set B (Nx0, Ny0, p0) in the
STAGS finite element model.

Resultant (e.g. lb/in) normal to the plane of screen, Nx0=0
        0
Resultant (e.g. lb/in) in the plane of the screen,    Ny0=0
        0
Normal pressure in STAGS model in Load Set B, p0=0
        0
Starting load factor for Load System A, STLD(1)=h

Use 1.0 for INDIC = 1 (linear buckling) analyses.

For transient restarts from nonlinear static runs that got stuck
because of singularities on the primary load path, use the load
factor corresponding to one or two steps back from the last step
converged. STAGS does not yet properly store information for the
last step successfully completed if the run stopped because of
maximum number of cuts in step. For example, if STAGS could not
get a converged solution for Load Step 31, then for some reason
Load Step 30 is not properly stored. Therefore, you should use
the load factor corresponding to Load Step 29 or perhaps 28.
PANDA2 will automatically supply an appropriate value for the
actual load factor to be used in the transient analysis. This
PANDA2-provided value will be a bit higher than the highest load
factor reached by STAGS in the case so that the structure will
start to move to a new state.

Starting load factor for Load System A, STLD(1)=1.0
  1.000000
Load factor increment for Load System A, STEP(1)=h

Use zero for linear buckling analysis (INDIC=1) and transient
analysis (INDIC=6).

Load factor increment for Load System A, STEP(1)=0.
  0.000000
Maximum load factor for Load System A, FACM(1)=h

Use FACM(1) = 1.0 for eigenvalue (INDIC=1) and transient (INDIC=6)
analysis types.

Maximum load factor for Load System A, FACM(1)=1.0
  1.000000
```

```
Starting load factor for Load System B, STLD(2)=0
        0
Load factor increment for Load System B, STEP(2)=0
        0
Maximum load factor for Load System B, FACM(2)=0
        0
How many eigenvalues do you want? NEIGS=h

This input datum is for the STAGS input file.

If the STAGS analysis type INDIC=1 (buckling of unloaded
structure) you will probably want NEIGS = 1 to 8.

If the STAGS analysis type INDIC=5 (vibration of loaded
structure) you will probably want NEIGS = 1  . The purpose
of the eigenvalue analysis in this case is to establish a
reasonable estimate for the time step in a subsequent dynamic
response analysis.

If the STAGS analysis type INDIC=4 (buckling of loaded
structure) you may well want to use NEIGS > 1  . NEIGS must
be less than twenty.  Probably should be from 4 to 8.

How many eigenvalues do you want? NEIGS=1
        1
Choose element type: 480 or 410 or 940=h


Descriptions of the 480, 410, and 940 elements appear
in the STAGS user's manual. The 480 finite element is
the one favored by the developer of PANDA2.

The 940 element usually converges from above.

Choose element type: 480 or 410 or 940=480
      480
Have you obtained buckling modes from STAGS for this case?=h

In order to include the effect of initial imperfections
in the STAGS model, you must have previously generated buckling
modes from either an INDIC = 1 (linear bifurcation) analysis or
an INDIC = 4 (bifurcation from nonlinear prebuckled state)
analysis.

If your answer is N the amplitude of the imperfection
WIMPL that you provided above will be set to zero, and your
STAGS run will therefore NOT include the effect of initial
imperfections.  If you want to include the effect of initial
imperfections, run STAGS with either the INDIC = 1 or
INDIC = 4 options first.

Have you obtained buckling modes from STAGS for this case?=n
n
Number of stringers in STAGS model of 360-deg. cylinder=h

The first stringer is at circ. angle, theta = 0 degrees
and the last stringer is at theta=(360-dtheta), in which
dtheta is the circ. angle between the lines of attachment
of adjacent stringers.

NOTE: Make sure that the stringer spacing is equal to
      the PANDA2 variable called B(1), or B(STR). You
      may have to run PANDA2 again with B(1) set so that
      there are exactly the right number of uniformly spaced
```

```
      stringers in the complete (360-deg.) cylindrical shell.

Number of stringers in STAGS model of 360-deg. cylinder=62
       62
Number of rings in the STAGS model of the panel=h

The first ring may be at the beginning of the panel
or it may be one-half ring spacing in from this edge,
depending on how you answer the next question.

NOTE: Make sure that the ring spacing is equal to the PANDA2
      variable called B(2), or B(RNG). You may have to run
      PANDA2 again with B(2) set so that there are exactly
      the right number of uniformly spaced rings over the
      axial length in the STAGS model. Alternatively, you
      may have to change the axial length of the STAGS model.

Number of rings in the STAGS model of the panel=10
       10
Are there rings at the ends of the panel?=y
y
Number of finite elements between adjacent stringers=h

If you are using the 410 finite element, make this
at least two.

NOTE: If you answer 0 PANDA2 will ask you to provide
the number of finite elements in the circumferential
direction. In such a case the stringers must be
smeared out.

Number of finite elements between adjacent stringers=1
        1
Number of finite elements between adjacent rings=h

If you are using the 410 finite element, make this
at least two.

NOTE: If you answer 0 PANDA2 will ask you to provide
the number of finite elements in the axial
direction. In such a case the rings must be
smeared out and the nodal point spacing in the
axial direction must be uniform.

Number of finite elements between adjacent rings=3
        3
Stringer model: 1 or 2 or 3 or 4 or 5(Type H(elp))=h

Input must be 1 or 2 or 3 or 4 or 5

      1 = all stringer segments are modeled as beams (210
          elements) that are attached to the cyl. shell.

      2 = stringer webs are modeled as shell branches (410 or 480)
          and any faying and/or outstanding flanges are modelled
          as beams (210 elements). The faying flanges are attached
          to the cylindrical shell and the outstanding flanges are
          attached at the tips of the stringer webs.

      3 = all stringer segments are modeled as shell branches.

      4 = stringer faying flange is modeled as beam (210 elements),
          but stringer web and stringer outstanding flange are
          modeled as shell branches.
```

```
      5 = the stringers are replaced by enforcement of a constraint
          that the normal displacement w be constant along the
          generator where the stringer would be attached to the
          cylindrical shell.

Stringer model: 1 or 2 or 3 or 4 or 5(Type H(elp))=3
        3
Ring model: 1 or 2 or 3 or 4 or 5 (Type H(elp))=3
        3
Reference surface of cyl: 1=outer, 0=middle, -1=inner=h

Choose either 1 or 0 or -1
If the stringers are external you may want to choose  1
If the stringers are internal you may want to choose -1
If the height of the stringers is large compared to
the thickness of the cyl. shell, you should choose    0
If you are planning to use fasteners, please choose 0

Reference surface of cyl: 1=outer, 0=middle, -1=inner=0
        0
Do you want to use fasteners (they are like rigid links)?=h

Usually you should answer N. However, if at the optimum
design the height of the stringers is not large compared
to the thickness of the cylindrical shell, and if you
answered 0 to the previous question about location of the
reference surface of the cylindrical shell. then you might
want to answer Y. Note that the use of fasteners
approximately numerically doubles the size of the case.

Fasteners are used to permit a gap between the reference
surface of the cylindrical shell and the roots of the
stringers and rings (when these stiffeners are modelled
as shell branches rather than as beams).

The fasteners act like tiny springs between "fastened" nodes.
The fastener spring constant is chosen automatically by
STAGSUNIT. It is set rather high in order that fasteners
act in a manner similar to rigid links.

Do you want to use fasteners (they are like rigid links)?=n
n
Are the stringers to be "smeared out"?=h

Generally, you should answer N.

Are the stringers to be "smeared out"?=n
n
Are the rings to be "smeared out"?=h

Generally, you should answer N.

Are the rings to be "smeared out"?=n
n
Number of nodes over height of stiffener webs, NODWEB=h

You must provide an odd integer.

First try a small number such as 3. In a convergence study,
or with models in which the cylindrical shell does not have
a huge number of nodes (huge = 500000 or more), or with models
in which there are not many stiffeners, you can try more,
especially if you suspect that significant web bending occurs
```

```
during buckling and/or nonlinear collapse. In STAGSUNIT the
webs of both stringers and rings will have the same number of
nodal points over their heights.

Number of nodes over height of stiffener webs, NODWEB=5
        5
Number of nodes over width of stringer flange, NDFLGS=5
        5
Number of nodes over width of ring flange, NDFLGR=5
        5

This section pertains to STAGS models generated via STAGSUNIT.
You will next be asked if you want stringer(s) and/or ring(s)
to have a denser finite element mesh than all the others
in the STAGS model. Ordinarily you should answer N (no).
First, you will be asked with regard to stringers, then
with regard to rings. For each category (stringers, rings),
if you answer Y, you will next be asked to give the stringer
number(s) or ring number(s) which are to have the higher nodal
point density. The stringers are numbered from the bottom to
the top (or right to left). The rings are numbered from
the bottom to the top (or left to right). See Fig. 2 of
the paper, "Difficulties in optimization...", AIAA Paper No.
2006-1943, AIAA SDM Meeting, Newport, RI, May 2006, for an
example of a STAGS model produced by STAGSUNIT. Stringer
numbers increase with coordinate y; ring numbers increase
with coordinate x.

Do you want stringer(s) with a high nodal point density?=h

The "nodal point density" referred to is with respect to
the stringer cross section, not the density along the axis
of the stringer. The density along the axis of the
stringer is the same as the density along the x-coordinate
in the panel skin.

You may wamt one or more stringers with a higher nodal
point density over the cross section than exists in the
others, especially if there occurs local stress and/or
buckling behavior not well represented by your previously
specified nodal point distribution over the cross section
used for all the stringers in your previous model.

Do you want stringer(s) with a high nodal point density?=n
n
Do you want ring(s) with a high nodal point density?=n
n

You will next be asked if the material in the STAGS model
can go plastic. For comparison with PANDA2 you will usually
answer N (no). However, occasionally you may want to answer
Y (yes). If you answer Y you will be asked to provide a
stress-strain curve for the material and the number of
integration points thru the wall thickness.

NOTE: Answer Y only if the panel and stiffeners are all
      made of only one isotropic material. This "plasticity"
      option does not work for panels made of more than one
      material. The "plasticity" option WILL work provided
      that all the materials specified in BEGIN (*.BEG file)
      have the same isotropic properties.

ANOTHER NOTE: The FIRST stress-strain coordinates you
              provide MUST agree with the elastic modulus
```

you provided in BEGIN, that is,
(first stress value)/(first strain value) = E

Is there plasticity in this STAGS model?=n
n
Do you want to use the "least-squares" model for torque?=h

Usually you should answer "y". In STAGSUNIT models, torque is always applied at x = 0. There are two choices:

1. STAGSUNIT can simply apply the appropriate value of Nxy at x = 0 as one of the loading components in Shell Unit No. 1.

2. STAGSUNIT can apply a torque about what the STAGS manual calls a "user-defined point". (This "user-defined point" is always located at the origin of the global coordinate system, (Xg,Yg,Zg)=(0,0,0) in STAGS models created via STAGSUNIT.)

Given the choice of one of the two options, STAGSUNIT automatically generates the proper input data for STAGS. The user of STAGSUNIT does not need to worry about the details of the modeling.

Option 2 is preferred because simple application of Nxy to the skin of the cylindrical shell at x = 0 generates, in nonlinear analyses, a small spurious hoop tension in a circumferential band of width approximately equal to a "boundary layer" width of about 2.0*SQRT(r*t) adjacent to x = 0. When you choose Option 2, STAGSUNIT automatically sets up a "user-defined" node at (Xg,Yg,Zg)=(0.,0.,0.) and sets up a finite element unit containing the torque, which is equal to Nxy*2*pi*r**2.

Do you want to use the "least-squares" model for torque?=y
y
Is stiffener sidesway permitted at the panel edges?=h

In the PANDA2 model it is assumed that stringer sidesway is permitted at the axially loaded ends of the panel, provided that the discretized skin-stringer module model is used. This is in order to obtain conservative designs. In STAGSMODEL and in STAGSUNIT you can choose whether or not this mode of deformation can occur.

By "stiffener sidesway" is meant a mode of deformation in which the tip of the stiffener can deflect sideways (in the y-direction in Fig. 9 on p. 492 of the long PANDA2 paper in COMPUTERS AND STRUCTURES, 1987).

In tests of panels "stringer sidesway" is usually prevented by friction at the axially loaded ends of the test specimen. In actual panels sidesway can occur if the stiffener tips or outstanding flanges are not attached to other structure.

To simulate the PANDA2 model with use of IQUICK = 0, answer Y. If IQUICK = 1 in your PANDA2 model, then you should probably answer N.

Is stiffener sidesway permitted at the panel edges?=n
n
Edges parallel to screen (0) in-plane deformable; (1) rigid=h

This input is for the STAGS model of the panel generated via the command "STAGSUNIT".

```
 Choose 0 if you think the two edges of the panel that run
 parallel to the rings (panel width-wise coordinate direction
 or circumferential direction) ARE relatively free to deform
 in the x-direction, that is, in the axial direction in the
 plane of the panel skin.

 Choose 1 if you think these two edges of the panel ARE NOT
 free to deform in the x-direction.

 NOTE:  The projection of these two edges onto the surface of
        the undeformed panel are ALWAYS free to move in the
        x-direction as straight lines.

 Edges parallel to screen (0) in-plane deformable; (1) rigid=0
        0

 Next, you will be asked to provide an index, IBCX0XL, which
 controls the distribution of axial displacement u over the
 heights of the webs of the stringers at axial stations x=0
 and x=XSTAGS, which are the axial coordinates at the two
 axially loaded ends of the STAGS model of the panel.
 The index, IBCX0XL, is defined as follows:

 IBCX0XL=0: no constraint of u is imposed over each stringer
            web height in the STAGS model of the panel.

 IBCX0XL=1: u=constant is imposed over the height of each
            stringer web in the STAGS model of the panel.

 There is the following reason for the introduction of the
 index, IBCX0XL: The panel is designed to buckle locally at
 a load less than the design load, that is, the factor of
 safety for local buckling, FSLOC, is less than 0.9. We
 wish to simulate in the STAGS model the same end conditions
 that exist in the PANDA2 model for the precollapsed state
 of the locally postbuckled panel. By forcing the axial
 displacement u to be constant over the heights of the
 stringer webs, we prevent the overall axial bending of the
 stringer-stiffened panel that occurs because of the shift
 in the neutral axis caused by the axial softening of the
 panel skin as it deforms in its locally postbuckled state.

 If you have a panel loaded reasonably far into its locally
 postbuckled state at the design load, say FSLOC is less
 than about 0.7, and if the applied load is equal to the
 design load, and if the STAGS model represents a sub-domain
 of the panel analyzed or optimized by PANDA2 (that is,
 XSTAGS is less than the axial length of the panel optimized
 by PANDA2), then you should probably set IBCXOXL = 1  .
 Otherwise, set IBCX0XL = 0  .

 Stringer web axial displacement index, IBCX0XL=0 or 1=0

----- This is the end of the "STAGSUNIT" interactive session -----
```

PART 3.6 Scroll upward on your screen in order to view the following output from STAGSUNIT

The following stuff zips by on your screen at the end of the interactive "STAGSUNIT" session:

```
----- beginning of stuff that zips by on your screen -----
 NODEX=  55; AXIAL NODAL SPACING, DX=
  5.5556E+00  5.5556E+00  5.5556E+00  5.5556E+00  5.5556E+00
  5.5556E+00  5.5556E+00  5.5556E+00  5.5556E+00  5.5556E+00
  5.5556E+00  5.5556E+00  5.5556E+00  5.5556E+00  5.5556E+00
  5.5556E+00  5.5556E+00  5.5556E+00  5.5556E+00  5.5556E+00
  5.5556E+00  5.5556E+00  5.5556E+00  5.5556E+00  5.5556E+00
  5.5556E+00  5.5556E+00  5.5556E+00  5.5556E+00  5.5556E+00
  5.5556E+00  5.5556E+00  5.5556E+00  5.5556E+00  5.5556E+00
  5.5556E+00  5.5556E+00  5.5556E+00  5.5556E+00  5.5556E+00
  5.5556E+00  5.5556E+00  5.5556E+00  5.5556E+00  5.5556E+00
  5.5556E+00  5.5556E+00  5.5556E+00  5.5556E+00  5.5556E+00
  5.5556E+00  5.5556E+00  5.5556E+00  5.5556E+00  5.5556E+00
 Row numbers of major ring locations, IROWRG(i)=
         1         7        13        19        25
        31        37        43        49        55
 Axial stations of major rings, XRINGX(i)=
  0.0000E+00  3.3333E+01  6.6667E+01  1.0000E+02  1.3333E+02
  1.6667E+02  2.0000E+02  2.3333E+02  2.6667E+02  3.0000E+02
 Column numbers of major stringer locations, ICOLST(i)=
         1         3         5         7         9
        11        13        15        17        19
        21        23        25        27        29
        31        33        35        37        39
        41        43        45        47        49
        51        53        55        57        59
        61        63        65        67        69
        71        73        75        77        79
        81        83        85        87        89
        91        93        95        97        99
       101       103       105       107       109
       111       113       115       117       119
       121       123
 Circumferential stations of major stringers, YSTRGX(i)=
  0.0000E+00  5.8065E+00  1.1613E+01  1.7419E+01  2.3226E+01
  2.9032E+01  3.4839E+01  4.0645E+01  4.6452E+01  5.2258E+01
  5.8065E+01  6.3871E+01  6.9677E+01  7.5484E+01  8.1290E+01
  8.7097E+01  9.2903E+01  9.8710E+01  1.0452E+02  1.1032E+02
  1.1613E+02  1.2194E+02  1.2774E+02  1.3355E+02  1.3935E+02
  1.4516E+02  1.5097E+02  1.5677E+02  1.6258E+02  1.6839E+02
  1.7419E+02  1.8000E+02  1.8581E+02  1.9161E+02  1.9742E+02
  2.0323E+02  2.0903E+02  2.1484E+02  2.2065E+02  2.2645E+02
  2.3226E+02  2.3806E+02  2.4387E+02  2.4968E+02  2.5548E+02
  2.6129E+02  2.6710E+02  2.7290E+02  2.7871E+02  2.8452E+02
  2.9032E+02  2.9613E+02  3.0194E+02  3.0774E+02  3.1355E+02
  3.1935E+02  3.2516E+02  3.3097E+02  3.3677E+02  3.4258E+02
  3.4839E+02  3.5419E+02

 ===============================================================
 VALUES USED TO GENERATE STAGS INPUT FILE *.INP
 Panel dimensions (axial,circ.)=(XSTAGS=  3.0000E+02, YSTAGS=  6.2832E+02)

   IREF,ISWAY,IBC12,IEDGE,ICLOSE,NODWEB=
     0     0     2     0     1     5

 MAJOR STRINGER QUANTITIES:
   NSTRNG,ISMRST,IBMSTR,NELSTR,ILINK1,IZSTIF(1),R=
     62      0      3      1      0      0  1.0000E+02

 MAJOR RING QUANTITIES:
   NRINGS,ISMRRG,IBMRNG,NELRNG,ILINK2,IZSTIF(2),IPOSNR,TY(2),TX(1)=
     10      0      3      3      0      0     -1  7.6896E-01  7.6896E-01
 ===============================================================
```

```
Membrane constitutive coefficients used to get EPS1 and EPS2
CS0(1,1),CS0(1,2),CS0(2,2)=  1.0233E+07  2.5350E+06  1.1335E+07

stringer web:iwall1,fnxstr(2),e1tab(iwall1),eps1,tx(3)=
  1 -2.9133E+03  1.0000E+07 -1.4295E-03  2.0380E-01
strng outflange:iwall1,fnxstr(3),e1tab(iwall1),eps1,tx(4)=
  2 -1.2079E+03  1.0000E+07 -1.4295E-03  8.4496E-02
ring web:iwall1,fnxrng(2),e1tab(iwall1),eps2,ty(3)=
  3 -2.3209E+04  1.0000E+07 -4.0912E-03  5.6729E-01
ring outflange:iwall1,fnxrng(3),e1tab(iwall1),eps2,ty(4)=
  4 -3.8672E+04  1.0000E+07 -4.0912E-03  9.4524E-01

EQUILIBRIUM FOR LOAD SET A...
Check for axial equilibrium with nominal stringer web height, H(1)=  7.8167E+00
FNX = Applied axial resultant, Nx;   FNXTOT = Computed value
FNXSTR(1,I),FNXSTR(2,I),FNXSTR(3,I)= Nx in stringer fayflange, web, outflange
FNXSKN(I) = Nx in skin + smeared stringers
     FNX       FNXTOT    FNXSKN(I)   FNXSTR(1,I)  FNXSTR(2,I)  FNXSTR(3,I)
-2.5000E+04 -2.5000E+04 -2.2451E+04  0.0000E+00 -2.9133E+03 -1.2079E+03
Substringer axial Nx, height=  0.0000E+00  0.0000E+00
Check for hoop equilibrium with nominal ring web height, H(2)=  9.7830E+00
FNY = Applied hoop  resultant, Ny;   FNYTOT = Computed value
FNXRNG(1,I),FNXRNG(2,I),FNXRNG(3,I)= Ny in ring fayflange, web, outflange
FNYSKN(I) = Ny in skin + smeared rings
     FNY       FNYTOT    FNYSKN(I)   FNXRNG(1,I)  FNXRNG(2,I)  FNXRNG(3,I)
-5.0000E+04 -5.0000E+04 -3.8195E+04  0.0000E+00 -2.3209E+04 -3.8672E+04
Subring     axial Nx, height=  0.0000E+00  0.0000E+00

Axial equilibrium (Nx added over x-cross section) off by  0.0000E+00 per cent.
Hoop  equilibrium (Ny added over y-cross section) off by  0.0000E+00 per cent.
==============================================================

Membrane constitutive coefficients used to get EPS1 and EPS2
CS0(1,1),CS0(1,2),CS0(2,2)=  1.0233E+07  2.5350E+06  1.1335E+07

stringer web:iwall1,fnxstr(2),e1tab(iwall1),eps1,tx(3)=
  1  0.0000E+00  1.0000E+07  0.0000E+00  2.0380E-01
strng outflange:iwall1,fnxstr(3),e1tab(iwall1),eps1,tx(4)=
  2  0.0000E+00  1.0000E+07  0.0000E+00  8.4496E-02
ring web:iwall1,fnxrng(2),e1tab(iwall1),eps2,ty(3)=
  3  0.0000E+00  1.0000E+07  0.0000E+00  5.6729E-01
ring outflange:iwall1,fnxrng(3),e1tab(iwall1),eps2,ty(4)=
  4  0.0000E+00  1.0000E+07  0.0000E+00  9.4524E-01

EQUILIBRIUM FOR LOAD SET B...
Check for axial equilibrium with nominal stringer web height, H(1)=  7.8167E+00
FNX = Applied axial resultant, Nx;   FNXTOT = Computed value
FNXSTR(1,I),FNXSTR(2,I),FNXSTR(3,I)= Nx in stringer fayflange, web, outflange
FNXSKN(I) = Nx in skin + smeared stringers
     FNX       FNXTOT    FNXSKN(I)   FNXSTR(1,I)  FNXSTR(2,I)  FNXSTR(3,I)
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
Substringer axial Nx, height=  0.0000E+00  0.0000E+00
Check for hoop equilibrium with nominal ring web height, H(2)=  9.7830E+00
FNY = Applied hoop  resultant, Ny;   FNYTOT = Computed value
FNXRNG(1,I),FNXRNG(2,I),FNXRNG(3,I)= Ny in ring fayflange, web, outflange
FNYSKN(I) = Ny in skin + smeared rings
     FNY       FNYTOT    FNYSKN(I)   FNXRNG(1,I)  FNXRNG(2,I)  FNXRNG(3,I)
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
Subring     axial Nx, height=  0.0000E+00  0.0000E+00

Axial equilibrium (Nx added over x-cross section) off by  0.0000E+00 per cent.
Hoop  equilibrium (Ny added over y-cross section) off by  0.0000E+00 per cent.
```

```
==============================================================
Major stringer logic,ILOGST= T
Column numbers of major stringer web/skin junctions, ICOLST(i)=
   1    3    5    7    9   11   13   15   17   19
  21   23   25   27   29   31   33   35   37   39
  41   43   45   47   49   51   53   55   57   59
  61   63   65   67   69   71   73   75   77   79
  81   83   85   87   89   91   93   95   97   99
 101  103  105  107  109  111  113  115  117  119
 121  123
Column numbers of sub-stringer/skin junctions, ICSTSB(i)=

Major ring logic,    ILOGRG= T
Row numbers of major ring web/skin junctions, IROWRG(i)=
   1    7   13   19   25   31   37   43   49   55
Row numbers of sub-ring/skin junctions, IRRGSB(i)=

All column numbers of stringer web/skin junctions, ICOLAL(i)=
   1    3    5    7    9   11   13   15   17   19
  21   23   25   27   29   31   33   35   37   39
  41   43   45   47   49   51   53   55   57   59
  61   63   65   67   69   71   73   75   77   79
  81   83   85   87   89   91   93   95   97   99
 101  103  105  107  109  111  113  115  117  119
 121  123
All row numbers of ring web/skin junctions, IROWAL(i)=
   1    7   13   19   25   31   37   43   49   55

EQUILIBRIUM FOR LOAD SET A...
Check for axial equilibrium with eff. stringer web height, HSTEFF=  8.2012E+00
FNX = Applied axial resultant, Nx;   FNXTOT = Computed value
FNXSTR(1,I),FNXSTR(2,I),FNXSTR(3,I)= Nx in stringer fayflange, web, outflange
FNXSKN(I) = Nx in skin + smeared stringers
     FNX       FNXTOT    FNXSKN(I)    FNXSTR(1,I)  FNXSTR(2,I)  FNXSTR(3,I)
-2.5000E+04 -2.5111E+04 -2.2451E+04  0.0000E+00 -2.9133E+03 -1.2079E+03
Substringer axial Nx, height=  0.0000E+00  0.0000E+00
Check for hoop equilibrium with effective ring web height, HRGEFF=  1.0167E+01
FNY = Applied hoop  resultant, Ny;   FNYTOT = Computed value
FNXRNG(1,I),FNXRNG(2,I),FNXRNG(3,I)= Ny in ring fayflange, web, outflange
FNYSKN(I) = Ny in skin + smeared rings
     FNY       FNYTOT    FNYSKN(I)    FNXRNG(1,I)  FNXRNG(2,I)  FNXRNG(3,I)
-5.0000E+04 -5.0268E+04 -3.8195E+04  0.0000E+00 -2.3209E+04 -3.8672E+04
Subring     axial Nx, height=  0.0000E+00  0.0000E+00

Axial equilibrium (Nx added over x-cross section) off by  4.4211E-01 per cent.
Hoop  equilibrium (Ny added over y-cross section) off by  5.3541E-01 per cent.
==============================================================

EQUILIBRIUM FOR LOAD SET B...
Check for axial equilibrium with eff. stringer web height, HSTEFF=  8.2012E+00
FNX = Applied axial resultant, Nx;   FNXTOT = Computed value
FNXSTR(1,I),FNXSTR(2,I),FNXSTR(3,I)= Nx in stringer fayflange, web, outflange
FNXSKN(I) = Nx in skin + smeared stringers
     FNX       FNXTOT    FNXSKN(I)    FNXSTR(1,I)  FNXSTR(2,I)  FNXSTR(3,I)
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
Substringer axial Nx, height=  0.0000E+00  0.0000E+00
Check for hoop equilibrium with effective ring web height, HRGEFF=  1.0167E+01
FNY = Applied hoop  resultant, Ny;   FNYTOT = Computed value
FNXRNG(1,I),FNXRNG(2,I),FNXRNG(3,I)= Ny in ring fayflange, web, outflange
FNYSKN(I) = Ny in skin + smeared rings
     FNY       FNYTOT    FNYSKN(I)    FNXRNG(1,I)  FNXRNG(2,I)  FNXRNG(3,I)
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
Subring     axial Nx, height=  0.0000E+00  0.0000E+00
```

```
 Axial equilibrium (Nx added over x-cross section) off by  0.0000E+00 per cent.
 Hoop  equilibrium (Ny added over y-cross section) off by  0.0000E+00 per cent.
 ============================================================
--------- end of stuff that zips by on your screen ---------


----------------------------------------------------------------------
```

PART 3.7 STAGSUNIT produces the file, cylstif.STG, which is valid input for the PANDA2 processor, STAGSUNIT

The user-provided input data during the STAGSUNIT interactive session has been saved in the file, cylstif.STG. A list of the file, cylstif.STG follows:

```
-------------- the cylstif.STG file (input for STAGSUNIT) ------------------
      n          $ Do you want a tutorial session and tutorial output?
         1       $ Choose type of STAGS analysis (1,3,4,5,6),INDIC
         0       $ Restart from ISTARTth load step (0=1st nonlinear soln), ISTART
   1.155000      $ Local buckling load factor from PANDA2, EIGLOC
      y          $ Are the dimensions in this case in inches?
         0       $ Nonlinear (0) or linear (1) kinematic relations?, ILIN
         1       $ Type 1 for closed (360-deg) cyl. shell, 0 otherwise, ITOTAL
       300       $ X-direction length of the STAGS model of the panel: XSTAGS
   628.3185      $ Panel length in the plane of the screen, L2
      y          $ Is the nodal point spacing uniform along the stringer axis?
        51       $ Number of nodes in the X-direction: NODEX
       101       $ Number of nodes in the Y-direction: NODEY
  -25000.00      $ Resultant (e.g. lb/in) normal to the plane of screen, Nx
  -50000.00      $ Resultant (e.g. lb/in) in the plane of the screen,    Ny
   0.000000      $ In-plane shear in load set A,                  Nxy
  -500.0000      $ Normal pressure in STAGS model in Load Set A, p
         0       $ Resultant (e.g. lb/in) normal to the plane of screen, Nx0
         0       $ Resultant (e.g. lb/in) in the plane of the screen,    Ny0
         0       $ Normal pressure in STAGS model in Load Set B, p0
   1.000000      $ Starting load factor for Load System A, STLD(1)
   0.000000      $ Load factor increment for Load System A, STEP(1)
   1.000000      $ Maximum load factor for Load System A, FACM(1)
         0       $ Starting load factor for Load System B, STLD(2)
         0       $ Load factor increment for Load System B, STEP(2)
         0       $ Maximum load factor for Load System B, FACM(2)
         1       $ How many eigenvalues do you want? NEIGS
       480       $ Choose element type: 480 or 410 or 940
      n          $ Have you obtained buckling modes from STAGS for this case?
        62       $ Number of stringers in STAGS model of 360-deg. cylinder
        10       $ Number of rings in the STAGS model of the panel
      y          $ Are there rings at the ends of the panel?
         1       $ Number of finite elements between adjacent stringers
         3       $ Number of finite elements between adjacent rings
         3       $ Stringer model: 1 or 2 or 3 or 4 or 5(Type H(elp))
         3       $ Ring model: 1 or 2 or 3 or 4 or 5 (Type H(elp))
         0       $ Reference surface of cyl: 1=outer, 0=middle, -1=inner
      n          $ Do you want to use fasteners (they are like rigid links)?
      n          $ Are the stringers to be "smeared out"?
      n          $ Are the rings to be "smeared out"?
         5       $ Number of nodes over height of stiffener webs, NODWEB
         5       $ Number of nodes over width of stringer flange, NDFLGS
         5       $ Number of nodes over width of ring flange, NDFLGR
      n          $ Do you want stringer(s) with a high nodal point density?
      n          $ Do you want ring(s) with a high nodal point density?
      n          $ Is there plasticity in this STAGS model?
      y          $ Do you want to use the "least-squares" model for torque?
      n          $ Is stiffener sidesway permitted at the panel edges?
```

```
         0      $ Edges parallel to screen (0) in-plane deformable; (1) rigid
         0      $ Stringer web axial displacement index, IBCX0XL=0 or 1
---------------- end of the cylstif.STG file (input for STAGSUNIT) -------------
```

The cylstif.STG file can be used as is or edited and then used as input
in future executions of STAGSUNIT.

PART 3.8 STAGSUNIT produces two files, cylstif.bin and cylstif.inp, that are valid input files for the STAGS general-purpose finite-element computer program

The PANDA2 processor, STAGSUNIT, has produced two files:

cylstif.bin
cylstif.inp

The STAGS file, cylstif.bin, is small, as follows:

```
------------ STAGS input file, cylstif.bin --------------------
 cylstif STAGS INPUT FOR STIFFENED CYL.(STAGSUNIT=SHELL UNITS)
 1, $ INDIC=1 is bifur.buckling; INDIC=3 is nonlinear BEGIN B-1
 1, $ IPOST=1 means save displacements every IPOSTth step
 0, $ ILIST =0 means normal batch-oriented output
 0, $ ICOR  =0 means projection in; 1 means not in.
 1, $ IMPTHE=index for imperfection theory.
 0, $ ICHIST=index for crack archive option
 0, $ IFLU  =0 means no fluid interaction.
 -1 $ ISOLVR= 0 means original solver; -1 new solver.END B-1 rec
 1.000E+00, $ STLD(1) = starting load factor, System A. BEGIN C-1 rec.
 0.000E+00, $ STEP(1) = load factor increment, System A
 1.000E+00, $ FACM(1) = maximum load factor, System A
 0.000E+00, $ STLD(2) = starting load factor, System B
 0.000E+00, $ STEP(2) = load factor increment, System B
 0.000E+00, $ FACM(2) = maximum load factor, System B
 0  $ ITEMP =0 means no thermal loads. END C-1 rec.
 10000, $ NSEC= number of CPU seconds before run termination
 0., $ DELEV is eigenvalue error tolerance (0=.00001)
 0  $ IPRINT=0 means print modes, iteration data, END D-2 rec.
  1, $ NEIGS= number of eigenvalues sought.  BEGIN D-3 rec.
 8.085E-01, $ SHIFT=initial eigenvalue shift
 0.000E+00, $ EIGA =lower bound of eigenvalue range
 0.000E+00  $ EIGB =upper bound of eigenvalue range.      END D-3 rec.
------------ end of STAGS input file, cylstif.bin -----------------
```

The cylstif.inp file is very large, and so is not completely
listed here. The beginning and end of cylstif.inp are
as follows:

```
--------- beginning of the long STAGS input file, cylstif.inp ------------
 cylstif STAGS INPUT FOR STIFFENED CYL.(STAGSUNIT=SHELL UNITS)
C
C Begin B-1 input data...
 0, $ IGRAV =0 means g = 386.4 inches per sec.**2; else B-4
 0, $ ICHECK=0 means normal execution
 0, $ ILIST =0 means normal batch-oriented output
 1,  $ INCBC=0:buck. bcs same as prebuc; 1: different.
 0,  $ NRUNIT=0 means plot entire model.
 3,  $ NROTS=3 means plot model with 3 rotations, as on B-1b.
 0  $ KDEV=1 means use PostScript file format for plot.END B-1
 1,  $ IROT=1 means rotation about global X-axis.BEGIN B-1b
```

```
-3.584E+01  $ ROT=0 means rotate 0 deg. about global X-axis.END B-1b
 2,  $ IROT=2 means rotation about global Y-axis.BEGIN B-1b
-1.314E+01  $ ROT=80 means rotate 80 deg. about global Y-axis.END B-1b
 3,  $ IROT=3 means rotation about global Z-axis.BEGIN B-1b
 3.563E+01  $ ROT=0 means rotate 0 deg. about global Z-axis.END B-1b
C
C Begin B-2 input data...
 145, $ NUNITS=number of shell units.            BEGIN B-2 rec.
   1, $ NUNITE=number of fastener strips + 1 = finite element units
   0, $ NSTFS = number of shell units with discrete stiffeners
  21, $ NINTS means number of connections between shell units
 273, $ NPATS=number of records for partial nodal compatibility
 -248, $ NCONST= number of Lagrange constraint conditions
 0, $ NIMPFS=number of bucklng modal imperfections.
 0, $ INERT = 0 means no inertial load records
 0  $ NINSR = 0 means no crack tip element sets. END B-2 rec.
C
C Begin B-3 input data...
 8, $ NTAM = number of entries in material tabl.BEGIN B-3 rec.
 6, $ NTAB = number of beam cross section entries
 7, $ NTAW = number of entries in shell wall table.
 0, $ NTAP = 0 means user parameters not included.
 2, $ NTAMT = 2 means two fastener element tables.
 1    $ NGCP = 1 means the GCP system will be used. END B-3 rec.
C
C Begin B-4, B-5 input data, if any...
C
C Begin F-1 input data (discretization)...
  55 125, $ F-1 NROWS( 1),  NCOLS( 1) unit 1 = cyl. shell
  55   5, $ f-1 strng.web NROWS(  2),NCOLS(  2) Unit   2 stringer no.   1
  55   5, $ f-1 outflange NROWS(  3),NCOLS(  3) Unit   3 stringer no.   1
  55   5, $ f-1 strng.web NROWS(  4),NCOLS(  4) Unit   4 stringer no.   2
  55   5, $ f-1 outflange NROWS(  5),NCOLS(  5) Unit   5 stringer no.   2
  55   5, $ f-1 strng.web NROWS(  6),NCOLS(  6) Unit   6 stringer no.   3


(many, many lines skipped to save space)


C Output control...
 0 0 0 0 0 0 0 0 0 0 0 0 0 $ r-1 output (end unit144)
C
C Begin unit145: ring no. 10 ring segment 2
C Begin outstanding flange of ring no. 10
 5 0 0 0 0 1 $ m-1 ISHELL,IGLOBE,NROWS,NCOLS,NLAYS,NFABS
  2.97848E+02  3.02152E+02  0.00000E+00  3.60000E+02  8.98325E+01 $ m-2 X1,X4,th1,th2,r
 -7  0 90.0  0.000E+00 0 0 0 $ m-5 IWALL,IWIMP,ZETA,ECZ,ILIN,IPLAS,IRAMP
  480    0    0 0  0  0  0 $ n-1 KELT,NNX,NNY,IRREG,IUGRID,INTEG,IPENL
C
C Input for b. c. and loading
 3  3  3  3  0  $ p-1 (IBLN(i), i=1,4), IBOND (b.c.)
C
  2 0 0 0 0 $ q-1 NSYS,NICS,NAMS,NUSS,NHINGE... (loading)
C  Load Set A, Ring No.  10
 1   4  0 $ q-2 ISYS, NN, USRLD
C
C Drilling freedoms suppressed in ring 10 outstanding flange
 0. -1 6   1   1 0 124 0 0 1 $ q-3 P,LT,LD,LI,LJ,LAX,NX..
 0. -1 6   2   1 0 124 0 0 1 $ q-3 P,LT,LD,LI,LJ,LAX,NX..
 0. -1 6   4   1 0 124 0 0 1 $ q-3 P,LT,LD,LI,LJ,LAX,NX..
 0. -1 6   5   1 0 124 0 0 1 $ q-3 P,LT,LD,LI,LJ,LAX,NX..
C  Load Set B, Ring No.  10
 2   4  0 $ q-2 ISYS, NN, USRLD
C
```

```
C Drilling freedoms suppressed in ring 10 outstanding flange
 0. -1 6   1   1 0 124 0 0 1 $ q-3 P,LT,LD,LI,LJ,LAX,NX..
 0. -1 6   2   1 0 124 0 0 1 $ q-3 P,LT,LD,LI,LJ,LAX,NX..
 0. -1 6   4   1 0 124 0 0 1 $ q-3 P,LT,LD,LI,LJ,LAX,NX..
 0. -1 6   5   1 0 124 0 0 1 $ q-3 P,LT,LD,LI,LJ,LAX,NX..
C Output control...
 0 0 0 0 0 0 0 0 0 0 0 0 0 $ r-1 output (end unit145)
C
C    A finite element unit is needed for the torque at x=0
 1 0 0 0 0. 0. 0. 111 111 $ s-1 Point of torque application
 1 0 0 0 0 0 1 $ u-1 One "least squares" loading case
 1 1           $ u-2 torque in Load Set A; 1 record needed.
C    The torque at x=0 is given by TORQUE = Nxy*2*pi*r**2
  0.000000E+00 1  4  1 $ u-3 P,LT.LD.LI; torque at userpoint 1 in ru sense
 1 146 1 0 1. $ u-8a NSQR,IUNIT,IROW,ICOL,SCALE. torque location
 1.  1 1 0 $ u-8b P,LU,LR.LC (wgt.,slave unit,row,col.)
 1 0 0 0 0 1 $ v-1 print displacement, nodal reaction
------- end of the long STAGS input file, cylstif.inp ----------------
```

The cylstif.bin and cylstif.inp files are valid input files
for STAGS.

PART 3.9 Execute STAGS

Next, go to a directory where you want to run STAGS
and run STAGS. At the writer's facility the correct
commands are as follows:

ftp feynman
<username>
<password>
cd /home/bush
put cylstif.bin
put cylstif.inp
telnet feynman
<username>
<password>
cd /home/bush
cat stags.execute
source /home/weiler/stags6/prc/initialize

```
==============================================================
Please enter your machine type ($STAGSMACHINE) from the list below:
If your machine is not listed, just enter one of the choices.

 "alpha"  - DEC Alpha workstation
 "amd64"  - 64-bit machine LINUX, Intel compilers
 "gfc64"  - 64-bit machine LINUX, gfortran/gcc compilers
 "cnvx"   - Convex C120 or C220 mainframe
 "cray"   - CRAY XMP/YMP mainframe
 "crayts" - CRAY TS super computer
 "dec"    - DEC-station 5000 or DEC-station 3100
 "hpo"    - Hewlet Packard 32-bit workstation
```

```
 "hp4"    - HP 64-bit architecture & code, 4-byte integers
 "hp8"    - HP 64-bit architecture & code, 8-byte integers
 "rs6k"   - IBM RS_6000 workstation
 "ia64"   - Intel 64-bit architecture & code, 8-byte integers
 "linux"  - Intel 32-bit architecture & code, 4-byte integers
 "macosx" - MAC OS X 32-bit architecture & code, 4-byte integers
 "ia32"   - same as (linux), but linux is preferred
 "sgi"    - Silicon Graphics 32-bit IRIS workstation
 "sgin"   - SGI 64-bit architecture, 32-bit object code
 "sgi4"   - SGI 64-bit architecture & code, 4-byte integers
 "sgi8"   - SGI 64-bit architecture & code, 8-byte integers
 "sol"    - SUN/SPARC Solaris workstation
 "star"   - Stardent Multi-Processor workstation
 "sun4"   - SUN-4/SPARC (Sun OS) workstation
=============================================================
Machine type is: hp8

 ****  You are initializing STAGS Version 5.0  ****

Your current machine type is: >>>>>>>>>>>> hp8 <<<<<<<<<<<<<
```

Next, execute stags:

stags -b cylstif

[The linear bifurcation buckling (INDIC=1)
 run requires about 12 minutes on feynman.]

From the STAGS output file, cylstif.out2, we have the following:

```
 CONVERGENCE HAS BEEN OBTAINED FOR EIGENVALUES   1 THROUGH    1
                    CRITICAL LOAD FACTOR COMBINATION
   NO.     EIGENVALUE   LOAD SYSTEM A  LOAD SYSTEM B    @DOF
     1   1.030548E+00   1.030548E+00   0.000000E+00   46315
```

---- end of fragment from the STAGS file, cylstif.out2 ----

**PART 3.10 Execute the STAGS post-processor, STAPL, to get
          a plot of a bifurcation buckling mode**

cp temp.pin cylstif.pin (input for STAPL is in the cylstif.pin file)

The cylstif.pin file is as follows:

```
------ cylstif.pin (input for STAPL, linear buckling mode -------
linear buckling of perfect shell from STAGS
  1  0  1  0  $PL-2  NPLOT,IPREP,IPRS,KDEV
     1     0     4     0     1  $PL-3  KPLOT,NUNIT,ITEM,STEP,MODE
    0.0   3  $PL-5  DSCALE,NROTS
  1  -0.35840000E+02   $PL-6  IROT,ROT
  2  -0.13140000E+02   $PL-6  IROT,ROT
  3   0.35630001E+02   $PL-6  IROT,ROT
------ end of cylstif.pin -------------------
```

Next, execute the STAGS post-processor, STAPL:

stapl cylstif (generates a file called cylstif.pdf, which shows the buckling mode.)

For plots of the STAGS model, see the two files:

7.cylstif.stagsunit.model.png
8.cylstif.stagsunit.model.zoom.png

For a plot of the buckling mode, see the file:

9.cylstif.stagsunit.eig1.png

PART 3.11 Compare with BIGBOSOR4 and PANDA2 predictions of local buckling

It is seen that buckling occurs only near the two ends of the cylindrical shell, and that the buckling load factor is somewhat lower than those predicted by BIGBOSOR4 and by PANDA2, as follows:

from BIGBOSOR4:

```
 BUCKLING LOADS FOLLOW
 AXIAL HALF WAVE NUMBER, N =       1

 EIGENVALUES =
    1.21180E+00    1.21651E+00    1.22461E+00

 **** CRITICAL EIGENVALUE AND WAVENUMBER ****
 EIGCRT=  1.2118E+00; NO. OF AXIAL HALF WAVES, NWVCRT=    1
 *****************************************************

 ***** EIGENVALUES AND MODE SHAPES *****
  EIGENVALUE(AXIAL HALF WAVES)
 =======================================
    1.2118E+00(     1)
 =======================================
```

From CHAPTER 14 in the PANDA2 file, cylstif.OPM:

```
 BUCKLING LOAD FACTORS FROM BOSOR4-TYPE DISCRETIZED MODEL...
          (skin-stringer discretized module of local buckling)
  AXIAL     BUCKLING        KNOCKDOWN FOR    KNOCKDOWN FOR      BUCKLING
  HALF-    LOAD FACTOR     TRANSVERSE SHEAR  IN-PLANE SHEAR    LOAD FACTOR
  WAVES  BEFORE KNOCKDOWN    DEFORMATION     LOADING AND/OR  AFTER KNOCKDOWN
                                               ANISOTROPY
    M        EIGOLD            KSTAR            KNOCK     EIGOLD*KSTAR*KNOCK
    1      1.21563E+00      9.83375E-01      1.00000E+00     1.19542E+00
```

PART 3.12 Produce and run a slightly different STAGS model

Run a STAGS model again, this time with the use of different input data as the last two entries of the cylstif.STG file. The new cylstif.STG file follows:

```
-------------- cylstif.STG file (input for STAGSUNIT) --------------
      n         $ Do you want a tutorial session and tutorial output?
         1      $ Choose type of STAGS analysis (1,3,4,5,6),INDIC
         0      $ Restart from ISTARTth load step (0=1st nonlinear soln), ISTART
   1.155000     $ Local buckling load factor from PANDA2, EIGLOC
      y         $ Are the dimensions in this case in inches?
         0      $ Nonlinear (0) or linear (1) kinematic relations?, ILIN
         1      $ Type 1 for closed (360-deg) cyl. shell, 0 otherwise, ITOTAL
       300      $ X-direction length of the STAGS model of the panel: XSTAGS
   628.3185     $ Panel length in the plane of the screen, L2
      y         $ Is the nodal point spacing uniform along the stringer axis?
        51      $ Number of nodes in the X-direction: NODEX
       101      $ Number of nodes in the Y-direction: NODEY
  -25000.00     $ Resultant (e.g. lb/in) normal to the plane of screen, Nx
  -50000.00     $ Resultant (e.g. lb/in) in the plane of the screen,    Ny
   0.000000     $ In-plane shear in load set A,                        Nxy
  -500.0000     $ Normal pressure in STAGS model in Load Set A, p
         0      $ Resultant (e.g. lb/in) normal to the plane of screen, Nx0
         0      $ Resultant (e.g. lb/in) in the plane of the screen,    Ny0
         0      $ Normal pressure in STAGS model in Load Set B, p0
   1.000000     $ Starting load factor for Load System A, STLD(1)
   0.000000     $ Load factor increment for Load System A, STEP(1)
   1.000000     $ Maximum load factor for Load System A, FACM(1)
         0      $ Starting load factor for Load System B, STLD(2)
         0      $ Load factor increment for Load System B, STEP(2)
         0      $ Maximum load factor for Load System B, FACM(2)
         1      $ How many eigenvalues do you want? NEIGS
       480      $ Choose element type: 480 or 410 or 940
      n         $ Have you obtained buckling modes from STAGS for this case?
        62      $ Number of stringers in STAGS model of 360-deg. cylinder
        10      $ Number of rings in the STAGS model of the panel
      y         $ Are there rings at the ends of the panel?
         1      $ Number of finite elements between adjacent stringers
         3      $ Number of finite elements between adjacent rings
         3      $ Stringer model: 1 or 2 or 3 or 4 or 5(Type H(elp))
         3      $ Ring model: 1 or 2 or 3 or 4 or 5 (Type H(elp))
         0      $ Reference surface of cyl: 1=outer, 0=middle, -1=inner
      n         $ Do you want to use fasteners (they are like rigid links)?
      n         $ Are the stringers to be "smeared out"?
      n         $ Are the rings to be "smeared out"?
         5      $ Number of nodes over height of stiffener webs, NODWEB
         5      $ Number of nodes over width of stringer flange, NDFLGS
         5      $ Number of nodes over width of ring flange, NDFLGR
      n         $ Do you want stringer(s) with a high nodal point density?
      n         $ Do you want ring(s) with a high nodal point density?
      n         $ Is there plasticity in this STAGS model?
      y         $ Do you want to use the "least-squares" model for torque?
      n         $ Is stiffener sidesway permitted at the panel edges?
NOTE-->  1      $ Edges parallel to screen (0) in-plane deformable; (1) rigid
NOTE-->  1      $ Stringer web axial displacement index, IBCX0XL=0 or 1
------------ end of the cylstif.STG file (input for STAGSUNIT) ------------
```

In the previous STAGS model the last two lines of the cylstif.STG file were as follows:

```
    0    $ Edges parallel to screen (0) in-plane deformable; (1) rigid
    0    $ Stringer web axial displacement index, IBCX0XL=0 or 1
```

STAGS is run again as described above, and the following lines now appear in the cylstif.out2 file:

------ a fragment from the STAGS file, cylstif.out2 ----------

```
 CONVERGENCE HAS BEEN OBTAINED FOR EIGENVALUES   1 THROUGH    1
                     CRITICAL LOAD FACTOR COMBINATION
   NO.    EIGENVALUE   LOAD SYSTEM A  LOAD SYSTEM B    @DOF
     1   1.186805E+00   1.186805E+00   0.000000E+00   89555

---- end of fragment from the STAGS file, cylstif.out2 -----
```

In the previous STAGS model the lowest bifurcation buckling eigenvalue was 1.030548E+00 (listed above in PART 3.9).

Compare the latest STAGS eigenvalue, 1.186805E+00, with the eigenvalue from BIGBOSOR4:

```
 BUCKLING LOADS FOLLOW
 AXIAL HALF WAVE NUMBER, N =       1

 EIGENVALUES =
    1.21180E+00    1.21651E+00    1.22461E+00

 **** CRITICAL EIGENVALUE AND WAVENUMBER ****
 EIGCRT=  1.2118E+00; NO. OF AXIAL HALF WAVES, NWVCRT=    1
```

Compare with the eigenvalue from CHAPTER 14 of the PANDA2 file, cylstif.OPM, for the perfect shell:

```
 BUCKLING LOAD FACTORS FROM BOSOR4-TYPE DISCRETIZED MODEL...
          (skin-stringer discretized module of local buckling)
  AXIAL     BUCKLING        KNOCKDOWN FOR    KNOCKDOWN FOR      BUCKLING
  HALF-    LOAD FACTOR     TRANSVERSE SHEAR  IN-PLANE SHEAR    LOAD FACTOR
  WAVES  BEFORE KNOCKDOWN    DEFORMATION     LOADING AND/OR  AFTER KNOCKDOWN
                                               ANISOTROPY
    M        EIGOLD             KSTAR            KNOCK     EIGOLD*KSTAR*KNOCK
    1      1.21563E+00       9.83375E-01      1.00000E+00     1.19542E+00
```

The latest buckling mode from STAGS is shown in the plot,

10.cylstif.stagsunit.eig1.rigidends.png

It is seen that this mode is no longer confined to the ring bays nearest the two ends of the cylindrical shell and that there is much better agreement with the predictions from BIGBOSOR4 and PANDA2.

PART 3.13 Produce and run a different STAGS model, one with smeared stringers

Run a STAGS model again, this time with the use of different input data in cylstif.STG. Now the stringers are smeared out, and the last two entries are changed back from 1 to 0. The new cylstif.STG file follows:

```
-------------- cylstif.STG file (input for STAGSUNIT) --------------
      n         $ Do you want a tutorial session and tutorial output?
         1      $ Choose type of STAGS analysis (1,3,4,5,6),INDIC
         0      $ Restart from ISTARTth load step (0=1st nonlinear soln), ISTART
   1.155000     $ Local buckling load factor from PANDA2, EIGLOC
```

```
      y          $ Are the dimensions in this case in inches?
         0       $ Nonlinear (0) or linear (1) kinematic relations?, ILIN
         1       $ Type 1 for closed (360-deg) cyl. shell, 0 otherwise, ITOTAL
       300       $ X-direction length of the STAGS model of the panel: XSTAGS
   628.3185      $ Panel length in the plane of the screen, L2
      y          $ Is the nodal point spacing uniform along the stringer axis?
        51       $ Number of nodes in the X-direction: NODEX
       101       $ Number of nodes in the Y-direction: NODEY
  -25000.00      $ Resultant (e.g. lb/in) normal to the plane of screen, Nx
  -50000.00      $ Resultant (e.g. lb/in) in the plane of the screen,    Ny
   0.000000      $ In-plane shear in load set A,                     Nxy
  -500.0000      $ Normal pressure in STAGS model in Load Set A, p
         0       $ Resultant (e.g. lb/in) normal to the plane of screen, Nx0
         0       $ Resultant (e.g. lb/in) in the plane of the screen,    Ny0
         0       $ Normal pressure in STAGS model in Load Set B, p0
   1.000000      $ Starting load factor for Load System A, STLD(1)
   0.000000      $ Load factor increment for Load System A, STEP(1)
   1.000000      $ Maximum load factor for Load System A, FACM(1)
         0       $ Starting load factor for Load System B, STLD(2)
         0       $ Load factor increment for Load System B, STEP(2)
         0       $ Maximum load factor for Load System B, FACM(2)
         1       $ How many eigenvalues do you want? NEIGS
       480       $ Choose element type: 480 or 410 or 940
      n          $ Have you obtained buckling modes from STAGS for this case?
        62       $ Number of stringers in STAGS model of 360-deg. cylinder
        10       $ Number of rings in the STAGS model of the panel
      y          $ Are there rings at the ends of the panel?
         1       $ Number of finite elements between adjacent stringers
         3       $ Number of finite elements between adjacent rings
         3       $ Stringer model: 1 or 2 or 3 or 4 or 5(Type H(elp))
         3       $ Ring model: 1 or 2 or 3 or 4 or 5 (Type H(elp))
         0       $ Reference surface of cyl: 1=outer, 0=middle, -1=inner
      n          $ Do you want to use fasteners (they are like rigid links)?
NOTE> y          $ Are the stringers to be "smeared out"?
      n          $ Are the rings to be "smeared out"?
         5       $ Number of nodes over height of stiffener webs, NODWEB
         5       $ Number of nodes over width of stringer flange, NDFLGS
         5       $ Number of nodes over width of ring flange, NDFLGR
      n          $ Do you want stringer(s) with a high nodal point density?
      n          $ Do you want ring(s) with a high nodal point density?
      n          $ Is there plasticity in this STAGS model?
      y          $ Do you want to use the "least-squares" model for torque?
      n          $ Is stiffener sidesway permitted at the panel edges?
NOTE->   0       $ Edges parallel to screen (0) in-plane deformable; (1) rigid
NOTE->   0       $ Stringer web axial displacement index, IBCX0XL=0 or 1
---------- end of the new cylstif.STG file -------------------
```

STAGS is run as described above, and the following lines
now appear in the cylstif.out2

```
---------- from the STAGS file, cylstif.out2 --------------

 CONVERGENCE HAS BEEN OBTAINED FOR EIGENVALUES  1 THROUGH   1
                     CRITICAL LOAD FACTOR COMBINATION
   NO.    EIGENVALUE   LOAD SYSTEM A  LOAD SYSTEM B    @DOF
     1   1.709327E+00   1.709327E+00   0.000000E+00   71745

---- end of fragment from the STAGS file, cylstif.out2 -----
```

Use STAPL to obtain a plot of the critical buckling mode.
The input in this case for STAPL is as follows:

```
------------ cylstif.pin file (input for STAPL) -----------
linear buckling of perfect shell from STAGS
  1  0  1  0  $PL-2  NPLOT,IPREP,IPRS,KDEV
     1     0     4     0     1  $PL-3  KPLOT,NUNIT,ITEM,STEP,MODE
    0.0   0  $PL-5  DSCALE,NROTS
--------- end of cylstif.pin file -----------------
```

The latest buckling mode from STAGS is shown in the plot,

11.cylstif.stagsunit.smrstr.eig1.png

Because the rings are internal, the plot hides most of the rings. We wish to obtain a plot of the same mode with the skin with its smeared stringers removed so that we can see the rings. The input data for STAPL in this particular is as follows:

```
------------ cylstif.pin file (input for STAPL) ----------
linear buckling of perfect shell from STAGS
  1  0  1  0  $PL-2  NPLOT,IPREP,IPRS,KDEV
     1    20     4     0     1  $PL-3  KPLOT,NUNIT,ITEM,STEP,MODE
 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
    0.0   0  $PL-5  DSCALE,NROTS
---------- end of cylstif.pin file ------------------
```

The buckling mode is displayed in the file,

12.cylstif.stagsunit.smrstr.eig1.rngs.png

PART 3.14 Compare with the predictions from BIGBOSOR4 and PANDA2

Compare the latest STAGS eigenvalue, 1.709327E+00, with the eigenvalues that correspond to ring sidesway obtained from BIGBOSOR4 (PART 2.7) and PANDA2 (PART 2.7):

From the BIGBOSOR4 model generated with the use of PANEL2:

```
 **** CRITICAL EIGENVALUE AND WAVENUMBER ****
 EIGCRT=  1.6141E+00; NO. OF CIRC. WAVES, NWVCRT=    4
 ****************************************************

 ***** EIGENVALUES AND MODE SHAPES *****
  EIGENVALUE(CIRC. WAVES)
 =======================================
    1.6929E+00(     2)
    1.6141E+00(     4) <--ring sidesway critical mode
    1.8127E+00(     6)    (Compare with PANDA2, CHAPTERs 22 & 26)
    2.2312E+00(     8)
```

From PANDA2, CHAPTER 22 of the cylstif.OPM file:

```
 Margin=  5.8244E-01  Lo-n Ring sidesway, discrete model, n=4   circ.halfwaves;FS=1.1
```

The corresponding buckling load factor is given by:
 (buckling load factor) = (factor of safety) x (Margin + 1.0) =
 (buckling load factor) = (1.1 x (0.58244 + 1.0) = 1.7407

PART 3.15 Produce and run a different STAGS model, one with smeared stringers and smeared rings

Run a STAGS model yet again, this time with the use of different input data in cylstif.STG. Now both the stringers and the rings are smeared out. The purpose of this run is to obtain the general buckling load factor and mode shape. The new cylstif.STG file follows:

```
-------------- cylstif.STG file (input for STAGSUNIT) --------------
      n         $ Do you want a tutorial session and tutorial output?
         1      $ Choose type of STAGS analysis (1,3,4,5,6),INDIC
         0      $ Restart from ISTARTth load step (0=1st nonlinear soln), ISTART
   1.155000     $ Local buckling load factor from PANDA2, EIGLOC
      y         $ Are the dimensions in this case in inches?
         0      $ Nonlinear (0) or linear (1) kinematic relations?, ILIN
         1      $ Type 1 for closed (360-deg) cyl. shell, 0 otherwise, ITOTAL
       300      $ X-direction length of the STAGS model of the panel: XSTAGS
   628.3185     $ Panel length in the plane of the screen, L2
      y         $ Is the nodal point spacing uniform along the stringer axis?
        51      $ Number of nodes in the X-direction: NODEX
       101      $ Number of nodes in the Y-direction: NODEY
  -25000.00     $ Resultant (e.g. lb/in) normal to the plane of screen, Nx
  -50000.00     $ Resultant (e.g. lb/in) in the plane of the screen,    Ny
   0.000000     $ In-plane shear in load set A,                  Nxy
  -500.0000     $ Normal pressure in STAGS model in Load Set A, p
         0      $ Resultant (e.g. lb/in) normal to the plane of screen, Nx0
         0      $ Resultant (e.g. lb/in) in the plane of the screen,    Ny0
         0      $ Normal pressure in STAGS model in Load Set B, p0
   1.000000     $ Starting load factor for Load System A, STLD(1)
   0.000000     $ Load factor increment for Load System A, STEP(1)
   1.000000     $ Maximum load factor for Load System A, FACM(1)
         0      $ Starting load factor for Load System B, STLD(2)
         0      $ Load factor increment for Load System B, STEP(2)
         0      $ Maximum load factor for Load System B, FACM(2)
         1      $ How many eigenvalues do you want? NEIGS
       480      $ Choose element type: 480 or 410 or 940
      n         $ Have you obtained buckling modes from STAGS for this case?
        62      $ Number of stringers in STAGS model of 360-deg. cylinder
        10      $ Number of rings in the STAGS model of the panel
      y         $ Are there rings at the ends of the panel?
         1      $ Number of finite elements between adjacent stringers
         3      $ Number of finite elements between adjacent rings
         3      $ Stringer model: 1 or 2 or 3 or 4 or 5(Type H(elp))
         3      $ Ring model: 1 or 2 or 3 or 4 or 5 (Type H(elp))
         0      $ Reference surface of cyl: 1=outer, 0=middle, -1=inner
      n         $ Do you want to use fasteners (they are like rigid links)?
NOTE> y         $ Are the stringers to be "smeared out"?
NOTE> y         $ Are the rings to be "smeared out"?
         5      $ Number of nodes over height of stiffener webs, NODWEB
         5      $ Number of nodes over width of stringer flange, NDFLGS
         5      $ Number of nodes over width of ring flange, NDFLGR
      n         $ Do you want stringer(s) with a high nodal point density?
      n         $ Do you want ring(s) with a high nodal point density?
      n         $ Is there plasticity in this STAGS model?
      y         $ Do you want to use the "least-squares" model for torque?
      n         $ Is stiffener sidesway permitted at the panel edges?
         0      $ Edges parallel to screen (0) in-plane deformable; (1) rigid
         0      $ Stringer web axial displacement index, IBCX0XL=0 or 1
```

```
---------- end of the new cylstif.STG file --------------------


 CONVERGENCE HAS BEEN OBTAINED FOR EIGENVALUES  1 THROUGH   1
                     CRITICAL LOAD FACTOR COMBINATION
   NO.    EIGENVALUE   LOAD SYSTEM A  LOAD SYSTEM B    @DOF
     1   2.507291E+00   2.507291E+00   0.000000E+00   16797
```

The buckling mode corresponding to the eigenvalue, 2.507291, is obtained by running the STAGS postprocessor, STAPL, with the following input:

```
-------------- cylstif.pin file (input for STAPL) -----------
linear buckling of perfect shell from STAGS
  1  0  1  0  $PL-2  NPLOT,IPREP,IPRS,KDEV
     1     0     4     0     1  $PL-3  KPLOT,NUNIT,ITEM,STEP,MODE
    0.0   3  $PL-5  DSCALE,NROTS
  1  -0.35840000E+02   $PL-6  IROT,ROT
  2  -0.13140000E+02   $PL-6  IROT,ROT
  3   0.35630001E+02   $PL-6  IROT,ROT
----------- end of cylstif.pin file ---------------------
```

The critical buckling mode is shown in the plot:

13.cylstif.stagsunit.genbuck.eig1.png

We wish to see an end view of the same general buckling mode. The input for the STAGS postprocessor, STAPL, follows:

```
-------------- cylstif.pin file (input for STAPL) -----------
linear buckling of perfect shell from STAGS
  1  0  1  0  $PL-2  NPLOT,IPREP,IPRS,KDEV
     1     0     4     0     1  $PL-3  KPLOT,NUNIT,ITEM,STEP,MODE
    0.0   3  $PL-5  DSCALE,NROTS
  1     0.0   $PL-6  IROT,ROT
  2    90.0   $PL-6  IROT,ROT
  3     0.0   $PL-6  IROT,ROT
----------- end of cylstif.pin file ---------------------
```

The end view of the critical buckling mode is shown in the plot:

14.cylstif.stagsunit.genbuck.eig1.endview.png

PART 3.16 Compare with the predictions from BIGBOSOR4 and PANDA2

Compare the latest STAGS eigenvalue, 2.507291E+00, with the eigenvalues that correspond to general buckling obtained from BIGBOSOR4 and PANDA2:

General buckling load factor from BIGBOSOR4:

```
 BUCKLING LOADS FOLLOW
 AXIAL HALF WAVE NUMBER, N =       1

 EIGENVALUES =
    2.88019E+00    3.62711E+00    4.75444E+00
```

```
 **** CRITICAL EIGENVALUE AND WAVENUMBER ****
 EIGCRT=  2.8802E+00; NO. OF AXIAL HALF WAVES, NWVCRT=    1
 ****************************************************
```

The general buckling load factor obtained from BIGBOSOR4
is unconservative because BIGBOSOR4 does not account for
transverse shear defomation (t.s.d.).

General buckling load factor from CHAPTER 26 of the
PANDA2 file, cylstif.OPM:

```
 general buckling: smeared stiffeners, C11=  1.0238E+07, radius, R=  1.0000E+02

 (lines skipped to save space)

 EIGMNC=  2.72E+00  2.72E+00  3.79E+00  6.72E+00  1.00E+17  2.72E+00  1.00E+17
 SLOPEX=  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
 MWAVEX=    1         1         2         4         0         1         1
 NWAVEX=    3         3         3         5         0         3         0

 (lines skipped to save space)

 Buckling load factor before t.s.d.=  2.7174E+00 After t.s.d.=  2.4489E+00

 (lines skipped to save space)

 Number of circumferential halfwaves in buckling pattern=  3.0000E+00
 Buckling load factor BEFORE knockdown for smeared stringers=  2.4489E+00
 Buckling load factor AFTER  knockdown for smeared stringers=  2.2966E+00

 General buckling load factor before and after knockdown:
 EIGGEN(before modification by 5 factors below)     =  2.2966E+00
 Knockdown factor from modal imperfection(s)        =  1.0000E+00
 Knockdown factor for smearing rings on cyl. shell  =  9.0000E-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=  2.0669E+00
```

The final general buckling load factor from PANDA2, 2.0669, is conservative
because the knockdown factors used in this case to compensate for the inherent
un-conservatveness of smearing rings and stringers are conservative in PANDA2
models in which ICONSV=1 .

Here is how the PANDA2 margins for general buckling vary with the
"conservativeness" index, ICONSV, set equal to its three possible values
in the cylstif.OPT file:

```
MARGINS FOR CURRENT DESIGN: LOAD CASE NO. 1, SUBCASE NO. 1
MAR. MARGIN
NO.  VALUE                  DEFINITION
ICONSV = 1:
14  8.24E-01 buck.(SAND);simp-support general buck;M=1;N=3;slope=0.;FS=1.1
ICONSV = 0:
13  9.73E-01 buck.(SAND);simp-support general buck;M=1;N=3;slope=0.;FS=1.1
ICONSV =-1:
13  1.19E+00 buck.(SAND);simp-support general buck;M=1;N=3;slope=0.;FS=1.1
```

ICONSV = 1, which is the recommended value, corresponds to the most
conservative PANDA2 model, and ICONSV = -1 corresponds to the least
conservative PANDA2 model.

The general buckling load factor is obtained from the general buckling margin from the following:

(buckling load factor) = (factor of safety) x (margin + 1.0)

For the least conservative PANDA2 model (ICONSV = -1) the general buckling load factor is given by

(buckling load factor) = 1.1 x (1.19 + 1.0) = 2.409

This general buckling load factor from PANDA2 is fairly close to that predicted by STAGS: 2.507.

PART 3.17 Produce and run a different STAGS model, one which covers only a small sub-domain of the entire shell, with all stiffener segments modeled as flexible shell units

Run a STAGS model yet again, this time with the use of different input data in cylstif.STG. Now only a sub-domain of the cylindrical shell is to be included in the STAGS model: a piece of the cylindrical shell that contains 5 stringer bays and 3 ring bays. There are rings along the two curved edges of the sub-domain, and there are stringers along the two straight edges of the sub-domain. These edge stiffeners have half the stiffness of the interior stiffeners. The purpose of this STAGS model is to be able to capture the local buckling load factor and mode shape with the use of a relatively dense mesh so that we have a converged prediction.

The new cylstif.STG file follows:

```
-------------- cylstif.STG file (input for STAGSUNIT) --------------
      n         $ Do you want a tutorial session and tutorial output?
         1      $ Choose type of STAGS analysis (1,3,4,5,6),INDIC
         0      $ Restart from ISTARTth load step (0=1st nonlinear soln), ISTART
   1.155000     $ Local buckling load factor from PANDA2, EIGLOC
      y         $ Are the dimensions in this case in inches?
         0      $ Nonlinear (0) or linear (1) kinematic relations?, ILIN
         0      $ Type 1 for closed (360-deg) cyl. shell, 0 otherwise, ITOTAL
       100      $ X-direction length of the STAGS model of the panel: XSTAGS
   50.67085     $ Panel length in the plane of the screen, L2
      y         $ Is the nodal point spacing uniform along the stringer axis?
        51      $ Number of nodes in the X-direction: NODEX
       101      $ Number of nodes in the Y-direction: NODEY
  -25000.00     $ Resultant (e.g. lb/in) normal to the plane of screen, Nx
  -50000.00     $ Resultant (e.g. lb/in) in the plane of the screen,    Ny
   0.000000     $ In-plane shear in load set A,                  Nxy
  -500.0000     $ Normal pressure in STAGS model in Load Set A, p
         0      $ Resultant (e.g. lb/in) normal to the plane of screen, Nx0
         0      $ Resultant (e.g. lb/in) in the plane of the screen,    Ny0
         0      $ Normal pressure in STAGS model in Load Set B, p0
   1.000000     $ Starting load factor for Load System A, STLD(1)
   0.000000     $ Load factor increment for Load System A, STEP(1)
   1.000000     $ Maximum load factor for Load System A, FACM(1)
         0      $ Starting load factor for Load System B, STLD(2)
         0      $ Load factor increment for Load System B, STEP(2)
         0      $ Maximum load factor for Load System B, FACM(2)
         1      $ How many eigenvalues do you want? NEIGS
       480      $ Choose element type: 480 or 410 or 940
      n         $ Have you obtained buckling modes from STAGS for this case?
```

```
         62       $ Number of stringers in STAGS model of 360-deg. cylinder
          4       $ Number of rings in the STAGS model of the panel
       y          $ Are there rings at the ends of the panel?
          3       $ Number of finite elements between adjacent stringers
          9       $ Number of finite elements between adjacent rings
          3       $ Stringer model: 1 or 2 or 3 or 4 or 5(Type H(elp))
          3       $ Ring model: 1 or 2 or 3 or 4 or 5 (Type H(elp))
          0       $ Reference surface of cyl: 1=outer, 0=middle, -1=inner
       n          $ Do you want to use fasteners (they are like rigid links)?
       n          $ Are the stringers to be "smeared out"?
       n          $ Are the rings to be "smeared out"?
          5       $ Number of nodes over height of stiffener webs, NODWEB
          5       $ Number of nodes over width of stringer flange, NDFLGS
          5       $ Number of nodes over width of ring flange, NDFLGR
       n          $ Do you want stringer(s) with a high nodal point density?
       n          $ Do you want ring(s) with a high nodal point density?
       n          $ Is there plasticity in this STAGS model?
       y          $ Do you want to use the "least-squares" model for torque?
       n          $ Is stiffener sidesway permitted at the panel edges?
       y          $ Do you want symmetry conditions along the straight edges?
          1       $ Edges parallel to screen (0) in-plane deformable; (1) rigid
          1       $ Stringer web axial displacement index, IBCX0XL=0 or 1
---------- end of the new cylstif.STG file --------------------
```

The following fragment appears in the STAGS output file, cylstif.out2:

```
 CONVERGENCE HAS BEEN OBTAINED FOR EIGENVALUES  1 THROUGH   1
                    CRITICAL LOAD FACTOR COMBINATION
   NO.    EIGENVALUE   LOAD SYSTEM A  LOAD SYSTEM B    @DOF
     1   1.181702E+00   1.181702E+00   0.000000E+00   15935
```

The buckling mode corresponding to the eigenvalue, 1.181702, is obtained by running the STAGS postprocessor, STAPL, with the following input:

```
-------------- cylstif.pin file (input for STAPL) -----------
linear buckling of perfect shell from STAGS
  1  0  1  0  $PL-2  NPLOT,IPREP,IPRS,KDEV
     1     0     4     0     1  $PL-3  KPLOT,NUNIT,ITEM,STEP,MODE
    0.0   3  $PL-5  DSCALE,NROTS
  1  -0.35840000E+02   $PL-6  IROT,ROT
  2  -0.13140000E+02   $PL-6  IROT,ROT
  3   0.35630001E+02   $PL-6  IROT,ROT
----------- end of cylstif.pin file ---------------------
```

The critical buckling mode is shown in the plot:

15.cylstif.stagsunit.locbuck.5x3bay.eig1.png

The eigenvalue, 1.181702, is close to the eignvalue, 1.186805, obtained from the STAGS model that includes the entire cylindrical shell with both rings and stringers modeled as flexible shell segments (shell units in STAGS jargon). Compare the two plots:

```
10.cylstif.stagsunit.eig1.rigidends.png        (360-degree model)
15.cylstif.stagsunit.locbuck.5x3bay.eig1.png   (5 x 3 bay model)
```

There is very good agreement between STAGS, BIGBOSOR4, and PANDA2 for the prediction of local buckling.

PART 3.18 Find the maximum effective stress from the same STAGS sub-domain model used in the previous PART

Next, find the maximum effective stress at load factor 1.0 from the same 5 x 3 bay STAGS model. In order to do this we run a STAGS nonlinear equilibrium run (INDIC = 3). The input file, cylstif.inp, is the same as for the linear bifurcation run (INDIC=1). However, the input file, cylstif.bin, is now as follows:

```
-------------- cylstif.bin file for nonlinear equilibrium ----------
optimized imperfect shell, nonlinear theory (INDIC=3)
 3, $ INDIC=1 is bifur.buckling; INDIC=3 is nonlinear BEGIN B-1
 1, $ IPOST=1 means save displacements every IPOSTth step
 0, $ ILIST =0 means normal batch-oriented output
 0, $ ICOR  =0 means projection in; 1 means not in.
 1, $ IMPTHE=index for imperfection theory.
 0, $ IOPTIM=0 means bandwith optimization will be performed
 0, $ IFLU  =0 means no fluid interaction.
 -1 $ ISOLVR= 0 means original solver; -1 new solver.END B-1 rec
 1.00, $ STLD(1) = starting load factor, System A. BEGIN C-1 rec.
 0.05, $ STEP(1) = load factor increment, System A
 1.0, $ FACM(1) = maximum load factor, System A
 0.000E+00, $ STLD(2) = starting load factor, System B
 0.000E+00, $ STEP(2) = load factor increment, System B
 0.000E+00, $ FACM(2) = maximum load factor, System B
 0  $ ITEMP =0 means no thermal loads. END C-1 rec.
   0, $ ISTART=restart from ISTARTth load step.   BEGIN D-1 rec.
 3500,$ NSEC= number of CPU seconds before run termination
  5,$ NCUT = number of times step size may be cut
  -20, $ NEWT = number of refactorings allowed
-1,$ NSTRAT=-1 means path length used as independent parameter
 0.0001,$ DELX=convergence tolerance
 0. $ WUND = 0 means initial relaxation factor =1.END D-1 rec.
 0,  1, 0  $ NPATH=0: Riks method, NEIGS=no.of eigs, NSOL=0: contin.  ET-1
------------- end of cylstif.bin file ---------------------------
```

The STAGS output file, cylstif.out2, includes the following:

```
---------------- beginning of fragment from the STAGS output file, cylstif.out2 ----------
-----
 BEGIN ITERATIONS FOR LOAD STEP     1,  DETA=   0.292884E+02,   PA=  0.100000E+01,   PB=
0.000000E+00
 ITERATION     RNORM           DNORM0             PA           ENERGY        DOF     RESIDUAL
DETRM
   EXP NEGRT       RFACT
         1   0.315580E-01   0.703508E-01   0.100000E+01   0.605530E+06  10218
0.105888E+05   0.157628E+01
165011    82   0.1000E+01
         2   0.660142E-02   0.668540E-02   0.100000E+01   0.603607E+06  10076
0.203753E+04   0.120615E+01
165009    82   0.1000E+01
         3   0.615675E-03   0.253234E-02   0.100000E+01   0.603792E+06  27629
0.110176E+02   0.297926E+01
165008    82   0.1000E+01
         4   0.121575E-04   0.302363E-05   0.100000E+01   0.603819E+06  27473
0.177187E+01   0.292803E+01
165008    82   0.1000E+01

 CP SEC =    46.480.  I/O REQSTS =   14429   WORDS USED =   3290795   WORDS TRANSFD =
7.49911E+07
  ISTEP,ITNMAX,TMAX,DETA =  1 1868 -1.461046860444531E-02 29.22589528856226
```

```
 Convergence obtained for load step     1
------------------ end of fragment from cylstif.out2 ----------------------
```

"Inner" fiber effective stresses from the 5 x 3 bay STAGS model:

We obtain a fringe plot of the distribution of the "inner fiber" effective stress via the STAGS post-processor, STAPL. The input for STAPL is as follows:

```
-------- cylstif.pin (input for STAPL for the inner fiber ------------
-------- effective stress distribution over the entire model) --------
nonlinear effective stress - inner fiber same view a linear buckling mode
  1  0  1  0  $PL-2  NPLOT,IPREP,IPRS,KDEV
  2   0  7  1  0 0 0 0 1 1 $PL-3  KPLOT,VIEW,ITEM,STEP,MODE,IFRNG,COLOR,ICOMP
   0.0   3  0.0  0.0  0.0 $PL-5  DSCALE,NROTS,LWSCALE,RNGMIN,RGMAX
  1  -0.35840000E+02   $PL-6  IROT,ROT
  2  -0.13140000E+02   $PL-6  IROT,ROT
  3   0.35630001E+02   $PL-6  IROT,ROT
-------- end of cylstif.pin file -----------------------
```

The fringe plot is contained in the following file:

16.cylstif.stagsunit.innerfibstress.5x3.png

We want to see the inner fiber effective stress in the skin only. The appropriate input for the STAGS post-processor, STAPL, is as follows:

```
-------- cylstif.pin (input for STAPL for the inner fiber ------------
-------- effective stress distribution over the panel skin only) -----
nonlinear effective stress - inner fiber same view a linear buckling mode
  1  0  1  0  $PL-2  NPLOT,IPREP,IPRS,KDEV
  2   1  7  1  0 0 0 0 1 1 $PL-3  KPLOT,VIEW,ITEM,STEP,MODE,IFRNG,COLOR,ICOMP
    1
   0.0   3  0.0  0.0  0.0 $PL-5  DSCALE,NROTS,LWSCALE,RNGMIN,RGMAX
  1  -0.35840000E+02   $PL-6  IROT,ROT
  2  -0.13140000E+02   $PL-6  IROT,ROT
  3   0.35630001E+02   $PL-6  IROT,ROT
-------- end of cylstif.pin file -----------------------
```

The inner fiber effective stress fringe plots are contained in the following two files:

17.cylstif.stagsunit.innerfibstress.5x3.skin.png
18.cylstif.stagsunit.innerfibstress.skin.zoom.png

PART 3.19 Compare with the PANDA2 prediction

PANDA2 predicts the maximum effective stress as follows from the list of margins for the perfect shell:

```
 MARGINS FOR CURRENT DESIGN: LOAD CASE NO. 1, SUBCASE NO. 1
 MAR. MARGIN
 NO.  VALUE                DEFINITION
 3  2.64E-01 eff.stress:matl=1,SKN,Dseg=2,node=6,layer=1,z=0.3845; MID.;FS=1.
```

```
 7  2.64E-01 eff.stress:matl=1,SKN,Iseg=2,at:n=6,layer=1,z=0.3845;-MID.;FS=1.
```

In the above "Dseg" means module segment number in the discretized model;
(The stress is computed in SUBROUTINE STRTHK).
"Iseg" means module segment number in the "closed form" model;
(The stress is computed in SUBROUTINE STRCON).

Dseg = Iseg = 2 is, in this case, the base under the stringer.
node=6 and n=6 mean the sixth nodal point in Dseg and Iseg, respectively.
The sixth nodal point is the nodal point that lies in the panel skin
where the skin intersects the root of the stringer web.

The effective stress is found from the margin by the following:

(effective stress) = (allowable stress)/[(margin + 1.0) x (factor of safety)]
(effective stress) = (60000)/[(0.264 +1.0) x 1.0] = 47468 psi

STAGS predicts a maximum inner fiber effective stress of 51010 psi,
not far above the prediction from PANDA2.

PART 3.20 "Outer" fiber effective stresses from the 5 x 3 bay STAGS model

We obtain a fringe plot of the distribution of the
"outer fiber" effective stress via the STAGS post-processor,
STAPL. The input for STAPL is as follows:

```
-------- cylstif.pin (input for STAPL for the outer fiber ------------
-------- effective stress distribution over the entire model) --------
nonlinear effective stress - outer fiber same view a linear buckling mode
  1  0  1  0  $PL-2  NPLOT,IPREP,IPRS,KDEV
  2   0  7  1  0 0 0 0 1 2 $PL-3  KPLOT,VIEW,ITEM,STEP,MODE,IFRNG,COLOR,ICOMP
   0.0   3  0.0  0.0  0.0 $PL-5  DSCALE,NROTS,LWSCALE,RNGMIN,RGMAX
  1  -0.35840000E+02   $PL-6  IROT,ROT
  2  -0.13140000E+02   $PL-6  IROT,ROT
  3   0.35630001E+02   $PL-6  IROT,ROT
-------- end of cylstif.pin file -----------------------
```

The fringe plot is contained in the following

cylstif.stagsunit.outerfibstress.5x3.png

We want to see the outer fiber effective stress in the skin only.
The appropriate input for the STAGS post-processor, STAPL, is
as follows:

```
-------- cylstif.pin (input for STAPL for the inner fiber ------------
-------- effective stress distribution over the panel skin only) -----
nonlinear effective stress - outer fiber same view a linear buckling mode
  1  0  1  0  $PL-2  NPLOT,IPREP,IPRS,KDEV
  2   1  7  1  0 0 0 0 1 2 $PL-3  KPLOT,VIEW,ITEM,STEP,MODE,IFRNG,COLOR,ICOMP
    1
   0.0   3  0.0  0.0  0.0 $PL-5  DSCALE,NROTS,LWSCALE,RNGMIN,RGMAX
  1  -0.35840000E+02   $PL-6  IROT,ROT
  2  -0.13140000E+02   $PL-6  IROT,ROT
  3   0.35630001E+02   $PL-6  IROT,ROT
-------- end of cylstif.pin file -----------------------
```

The stress fringe plot is contained in the following file:

19.cylstif.stagsunit.outerfibstress.skin.zoom.png

STAGS predicts "outer" fiber effective stresses that are about the same as the "inner" fiber effective stresses because there is not much bending of the optimized stiffened shell. The maximum "outer" fiber effective stress in the skin predicted by STAGS is 50250 psi compared to 51010 psi for the maximum "inner" fiber effective stress in the skin.

The STAGS model exhibits stress concentrations in the stringer webs near the roots of the stringer webs. These stress concentrations cannot be predicted by PANDA2, of course. In actual stiffened cylindrical shells the wall thicknesses would be increased in the immediate neighborhoods of the curved edges of the shell in order to reduce possible local stress concentrations there. The very local stress concentrations at the roots of three of the stringer webs are displayed in the file:

20.cylstif.stagsunit.innerfibstress.webzoom.png

The maximum effective stress, 57860, occurs at the roots of the stringer webs at the ends of the shell.

PART 3.21 Produce and run a different STAGS model, one which again covers only a small 6 x 3 bay sub-domain of the entire shell, with all ring segments modeled as flexible shell units and with the stringers smeared out

Next, use a new sub-domain model to determine from STAGS the lowest buckling load factor that corresponds to inter-ring buckling. In this sub-domain model the stringers are smeared out and the rings are modeled with little flexible shell segments (shell units in STAGS jargon). The STAGS model is generated by STAGSUNIT with the following input data (cylstif.STG file):

```
-------------- cylstif.STG (input data for STAGSUNIT) --------------
-------------- for a STAGS model the purpose of which --------------
-------------- is to search for inter-ring buckling ----------------
      n         $ Do you want a tutorial session and tutorial output?
         1      $ Choose type of STAGS analysis (1,3,4,5,6),INDIC
         0      $ Restart from ISTARTth load step (0=1st nonlinear soln), ISTART
   1.155000     $ Local buckling load factor from PANDA2, EIGLOC
      y         $ Are the dimensions in this case in inches?
         0      $ Nonlinear (0) or linear (1) kinematic relations?, ILIN
         0      $ Type 1 for closed (360-deg) cyl. shell, 0 otherwise, ITOTAL
       100      $ X-direction length of the STAGS model of the panel: XSTAGS
   60.80502     $ Panel length in the plane of the screen, L2
      y         $ Is the nodal point spacing uniform along the stringer axis?
        51      $ Number of nodes in the X-direction: NODEX
       101      $ Number of nodes in the Y-direction: NODEY
  -25000.00     $ Resultant (e.g. lb/in) normal to the plane of screen, Nx
  -50000.00     $ Resultant (e.g. lb/in) in the plane of the screen,    Ny
   0.000000     $ In-plane shear in load set A,                        Nxy
  -500.0000     $ Normal pressure in STAGS model in Load Set A, p
         0      $ Resultant (e.g. lb/in) normal to the plane of screen, Nx0
         0      $ Resultant (e.g. lb/in) in the plane of the screen,    Ny0
         0      $ Normal pressure in STAGS model in Load Set B, p0
   1.000000     $ Starting load factor for Load System A, STLD(1)
```

```
   0.000000     $ Load factor increment for Load System A, STEP(1)
   1.000000     $ Maximum load factor for Load System A, FACM(1)
         0      $ Starting load factor for Load System B, STLD(2)
         0      $ Load factor increment for Load System B, STEP(2)
         0      $ Maximum load factor for Load System B, FACM(2)
         1      $ How many eigenvalues do you want? NEIGS
       480      $ Choose element type: 480 or 410 or 940
      n         $ Have you obtained buckling modes from STAGS for this case?
        62      $ Number of stringers in STAGS model of 360-deg. cylinder
         4      $ Number of rings in the STAGS model of the panel
      y         $ Are there rings at the ends of the panel?
         3      $ Number of finite elements between adjacent stringers
         9      $ Number of finite elements between adjacent rings
         3      $ Stringer model: 1 or 2 or 3 or 4 or 5(Type H(elp))
         3      $ Ring model: 1 or 2 or 3 or 4 or 5 (Type H(elp))
         0      $ Reference surface of cyl: 1=outer, 0=middle, -1=inner
      n         $ Do you want to use fasteners (they are like rigid links)?
NOTE> y         $ Are the stringers to be "smeared out"?
      n         $ Are the rings to be "smeared out"?
         5      $ Number of nodes over height of stiffener webs, NODWEB
         5      $ Number of nodes over width of stringer flange, NDFLGS
         5      $ Number of nodes over width of ring flange, NDFLGR
      n         $ Do you want stringer(s) with a high nodal point density?
      n         $ Do you want ring(s) with a high nodal point density?
      n         $ Is there plasticity in this STAGS model?
      y         $ Do you want to use the "least-squares" model for torque?
      n         $ Is stiffener sidesway permitted at the panel edges?
      y         $ Do you want symmetry conditions along the straight edges?
         0      $ Edges parallel to screen (0) in-plane deformable; (1) rigid
         0      $ Stringer web axial displacement index, IBCX0XL=0 or 1
-------------- end of the cylstif.STG file for inter-ring buckling ----------
```

The STAGS input file, cylstif.bin, is as follows:

```
------------ cylstif.bin file (one of the 2 input files for STAGS -----------
 cylstif STAGS INPUT FOR STIFFENED CYL.(STAGSUNIT=SHELL UNITS)
 1, $ INDIC=1 is bifur.buckling; INDIC=3 is nonlinear BEGIN B-1
 1, $ IPOST=1 means save displacements every IPOSTth step
 0, $ ILIST =0 means normal batch-oriented output
 0, $ ICOR  =0 means projection in; 1 means not in.
 1, $ IMPTHE=index for imperfection theory.
 0, $ ICHIST=index for crack archive option
 0, $ IFLU  =0 means no fluid interaction.
 -1 $ ISOLVR= 0 means original solver; -1 new solver.END B-1 rec
 1.000E+00, $ STLD(1) = starting load factor, System A. BEGIN C-1 rec.
 0.000E+00, $ STEP(1) = load factor increment, System A
 1.000E+00, $ FACM(1) = maximum load factor, System A
 0.000E+00, $ STLD(2) = starting load factor, System B
 0.000E+00, $ STEP(2) = load factor increment, System B
 0.000E+00, $ FACM(2) = maximum load factor, System B
 0  $ ITEMP =0 means no thermal loads. END C-1 rec.
 10000, $ NSEC= number of CPU seconds before run termination
 0., $ DELEV is eigenvalue error tolerance (0=.00001)
 0  $ IPRINT=0 means print modes, iteration data, END D-2 rec.
  8, $ NEIGS= number of eigenvalues sought.  BEGIN D-3 rec.
 2.0, $ SHIFT=initial eigenvalue shift
 0.000E+00, $ EIGA =lower bound of eigenvalue range
 0.000E+00  $ EIGB =upper bound of eigenvalue range.      END D-3 rec.
----------------- end of the cylstif.bin file ----------------------
```

(The cylstif.bin file is as listed above because we need to search over several buckling modes in order to determine the lowest eigenvalue

that corresponds primarily to buckling of the skin-with-smeared-
stringers between adjacent rings.)

STAGS produces the following lines in the cylstif.out2 file:

```
------------- fragment of the cylstif.out2 file ------------------------
 CONVERGENCE HAS BEEN OBTAINED FOR EIGENVALUES  1 THROUGH   8
                     CRITICAL LOAD FACTOR COMBINATION
   NO.    EIGENVALUE   LOAD SYSTEM A  LOAD SYSTEM B    @DOF
     1   1.891302E+00   1.891302E+00   0.000000E+00   38679
     2   1.894643E+00   1.894643E+00   0.000000E+00   43179
     3   1.908025E+00   1.908025E+00   0.000000E+00   43029
     4   1.910256E+00   1.910256E+00   0.000000E+00   38781
     5   2.035811E+00   2.035811E+00   0.000000E+00   16365 <--lowest inter-ring
     6   2.079418E+00   2.079418E+00   0.000000E+00   16965    buckling mode
     7   2.140823E+00   2.140823E+00   0.000000E+00   33339
     8   2.141343E+00   2.141343E+00   0.000000E+00   47883
---------- end of fragment of the cylstif.out2 file ----------------
```

It turns out that the lowest eigenvalue that corresponds primarily to buckling of the skin-with-smeared-stringers between adjacent rings is Eigenvalue no. 5. The buckling load factor is 2.035811.

The STAGS post-processor, STAPL, is used to obtain the inter-ring buckling mode. The input for STAPL is as follows:

```
---------------- cylstif.pin file (input for STAPL) ----------------
linear buckling of perfect shell from STAGS
  1  0  1  0  $PL-2  NPLOT,IPREP,IPRS,KDEV
     1     0     4     0     5  $PL-3  KPLOT,NUNIT,ITEM,STEP,MODE
    0.0   3  $PL-5  DSCALE,NROTS
  1  -0.35840000E+02   $PL-6  IROT,ROT
  2  -0.13140000E+02   $PL-6  IROT,ROT
  3   0.35630001E+02   $PL-6  IROT,ROT
--------- end of cylstif.pin file ---------------------------------
```

A plot of the appropriate buckling mode obtained from STAGS is contained in the file:

21.cylstif.stagsunit.6x3.smrstr.eig5.png

PART 3.22 Compare STAGS prediction with those from BIGBOSOR4 and PANDA2

From PANEL2 and BIGBOSOR4 we obtain the following buckling load factors for an analogous type of buckling:

```
 ***** EIGENVALUES AND MODE SHAPES *****
  EIGENVALUE(CIRC. WAVES)
 =======================================
    1.6929E+00(     2)
    1.6141E+00(     4) <--ring sidesway critical mode
    1.8127E+00(     6)    (Compare with PANDA2, CHAPTERs 22 & 26)
    2.2312E+00(     8)
    2.7896E+00(    10)
    3.3854E+00(    12)
```

```
    3.8828E+00(    14)
    3.8381E+00(    16)
    3.3807E+00(    18)
    3.0163E+00(    20)
    2.7499E+00(    22)
    2.5632E+00(    24)
    2.4399E+00(    26)
    2.3680E+00(    28)
    2.3381E+00(    30) <--inter-ring critical mode
    2.3432E+00(    32)    (Compare with PANDA2, CHAPTER 22)
    2.3782E+00(    34)
    2.4388E+00(    36)
    2.5220E+00(    38)
    2.6253E+00(    40)
 =======================================
```

The inter-ring buckling mode analogous to that displayed in the file, 21.cylstif.stagsunit.6x3.smrstr.eig5.png, is the BIGBOSOR4 mode with 30 circumferential waves: the mode associated with the eigenvalue = 2.3381.

ICONSV = 1:
From CHAPTER 22 of the PANDA2 file, cylstif.OPM, we have, for ICONSV=1:

```
 BUCKLING LOAD FACTORS FROM BOSOR4-TYPE DISCRETIZED ("STAGS-worthy) MODEL...
          (skin-smeared-stringer-ring discretized module)
  HOOP      BUCKLING        KNOCKDOWN FOR    KNOCKDOWN FOR      BUCKLING
  HALF-    LOAD FACTOR     TRANSVERSE SHEAR  IN-PLANE SHEAR    LOAD FACTOR
  WAVES  BEFORE KNOCKDOWN    DEFORMATION     LOADING AND/OR  AFTER KNOCKDOWN
                                               ANISOTROPY
    n        EIGOLD             KSTAR             KNOCK     EIGOLD*KSTAR*KNOCK
   30      2.21541E+00       1.00000E+00      1.00000E+00     2.21541E+00
   33      2.24156E+00       1.00000E+00      1.00000E+00     2.24156E+00
   27      2.26516E+00       1.00000E+00      1.00000E+00     2.26516E+00
 Buckling load factor before t.s.d.=  2.2154E+00 After t.s.d.=  2.0332E+00
```

The buckling load factor, 2.0332, is further "knocked down" by PANDA2 as follows:

```
 knockdown for smeared stringers from SUB.EIGMOD,
                                          SMRFAC=  5.7026E-01 (ICONSV = 1)
 Buckling load factor BEFORE knockdown for smeared stringers=  2.0332E+00
 Buckling load factor AFTER  knockdown for smeared stringers=  1.1595E+00
------------------------------------
```

ICONSV = -1:
From CHAPTER 22 of the PANDA2 file, cylstif.OPM, we have, for ICONSV=-1:

```
 BUCKLING LOAD FACTORS FROM BOSOR4-TYPE DISCRETIZED ("STAGS-worthy) MODEL...
          (skin-smeared-stringer-ring discretized module)
  HOOP      BUCKLING        KNOCKDOWN FOR    KNOCKDOWN FOR      BUCKLING
  HALF-    LOAD FACTOR     TRANSVERSE SHEAR  IN-PLANE SHEAR    LOAD FACTOR
  WAVES  BEFORE KNOCKDOWN    DEFORMATION     LOADING AND/OR  AFTER KNOCKDOWN
                                               ANISOTROPY
    n        EIGOLD             KSTAR             KNOCK     EIGOLD*KSTAR*KNOCK
   30      2.21541E+00       1.00000E+00      1.00000E+00     2.21541E+00
   33      2.24156E+00       1.00000E+00      1.00000E+00     2.24156E+00
   27      2.26516E+00       1.00000E+00      1.00000E+00     2.26516E+00
 Buckling load factor before t.s.d.=  2.2154E+00 After t.s.d.=  2.1201E+00

 knockdown for smeared stringers from SUB.EIGMOD,
                                          SMRFAC=  1.0000E+00 (ICONSV = 0)
 Buckling load factor BEFORE knockdown for smeared stringers=  2.1201E+00
 Buckling load factor AFTER  knockdown for smeared stringers=  2.1201E+00
```

```
----------------------------------

ICONSV = 0:
From CHAPTER 22 of the PANDA2 file, cylstif.OPM, we have, for ICONSV= 0:

 BUCKLING LOAD FACTORS FROM BOSOR4-TYPE DISCRETIZED ("STAGS-worthy) MODEL...
           (skin-smeared-stringer-ring discretized module)
  HOOP      BUCKLING        KNOCKDOWN FOR    KNOCKDOWN FOR      BUCKLING
  HALF-    LOAD FACTOR     TRANSVERSE SHEAR  IN-PLANE SHEAR    LOAD FACTOR
  WAVES  BEFORE KNOCKDOWN    DEFORMATION     LOADING AND/OR  AFTER KNOCKDOWN
                                               ANISOTROPY
    n        EIGOLD             KSTAR             KNOCK     EIGOLD*KSTAR*KNOCK
   30      2.21541E+00       1.00000E+00      1.00000E+00     2.21541E+00
   33      2.24156E+00       1.00000E+00      1.00000E+00     2.24156E+00
   27      2.26516E+00       1.00000E+00      1.00000E+00     2.26516E+00
 Buckling load factor before t.s.d.=  2.2154E+00 After t.s.d.=  2.1201E+00

 knockdown for smeared stringers from SUB.EIGMOD,
                                         SMRFAC=  1.0000E+00 (ICONSV = 0)
 Buckling load factor BEFORE knockdown for smeared stringers=  2.1201E+00
 Buckling load factor AFTER  knockdown for smeared stringers=  2.1201E+00
---------------------------------
```

The eigenvalue, 2.035811, from STAGS that corresponds to inter-ring buckling of skin plus smeared stringers agrees very well with those from PANDA2 obtained before knockdown for compensating for the inherent unconservativeness of smearing the stringers. As we shall see from the next STAGS model, treating the stringers as flexible shell segments (shell units in STAGS jargon) leads to an inter-ring buckling load factor (eigenvalue) only about 6 per cent less than that from the STAGS model in which the stringers are smeared. Therefore, in this particular case, PANDA2 yields a conservative result when the "conservativeness" index, ICONSV is set equal to unity.

PART 3.23 Produce and run a different STAGS model, one which covers the same 6 x 3 bay sub-domain of the entire shell, with all stiffener segments modeled as flexible shell units. Note that now the STAGS index ILIN = 1, not 0

STAGS runs with same model as in PART 3.21 except that instead of being smeared, the stringers are now modeled as flexible shell segments and the STAGS index, ILIN, is set equal to unity. The input file for STAGSUNIT, cylstif.STG, follows:

```
----------------- cylstif.STG (input for STAGSUNIT) ---------------
      n         $ Do you want a tutorial session and tutorial output?
         1      $ Choose type of STAGS analysis (1,3,4,5,6),INDIC
         0      $ Restart from ISTARTth load step (0=1st nonlinear soln), ISTART
   1.155000     $ Local buckling load factor from PANDA2, EIGLOC
      y         $ Are the dimensions in this case in inches?
NOTE->   1      $ Nonlinear (0) or linear (1) kinematic relations?, ILIN
         0      $ Type 1 for closed (360-deg) cyl. shell, 0 otherwise, ITOTAL
       100      $ X-direction length of the STAGS model of the panel: XSTAGS
   60.80502     $ Panel length in the plane of the screen, L2
      y         $ Is the nodal point spacing uniform along the stringer axis?
        51      $ Number of nodes in the X-direction: NODEX
       101      $ Number of nodes in the Y-direction: NODEY
  -25000.00     $ Resultant (e.g. lb/in) normal to the plane of screen, Nx
  -50000.00     $ Resultant (e.g. lb/in) in the plane of the screen,    Ny
   0.000000     $ In-plane shear in load set A,                  Nxy
```

```
  -500.0000     $ Normal pressure in STAGS model in Load Set A, p
        0       $ Resultant (e.g. lb/in) normal to the plane of screen, Nx0
        0       $ Resultant (e.g. lb/in) in the plane of the screen,    Ny0
        0       $ Normal pressure in STAGS model in Load Set B, p0
   1.000000     $ Starting load factor for Load System A, STLD(1)
   0.000000     $ Load factor increment for Load System A, STEP(1)
   1.000000     $ Maximum load factor for Load System A, FACM(1)
        0       $ Starting load factor for Load System B, STLD(2)
        0       $ Load factor increment for Load System B, STEP(2)
        0       $ Maximum load factor for Load System B, FACM(2)
        1       $ How many eigenvalues do you want? NEIGS
      480       $ Choose element type: 480 or 410 or 940
     n          $ Have you obtained buckling modes from STAGS for this case?
       62       $ Number of stringers in STAGS model of 360-deg. cylinder
        4       $ Number of rings in the STAGS model of the panel
     y          $ Are there rings at the ends of the panel?
        3       $ Number of finite elements between adjacent stringers
        9       $ Number of finite elements between adjacent rings
        3       $ Stringer model: 1 or 2 or 3 or 4 or 5(Type H(elp))
        3       $ Ring model: 1 or 2 or 3 or 4 or 5 (Type H(elp))
        0       $ Reference surface of cyl: 1=outer, 0=middle, -1=inner
     n          $ Do you want to use fasteners (they are like rigid links)?
     n          $ Are the stringers to be "smeared out"?
     n          $ Are the rings to be "smeared out"?
        5       $ Number of nodes over height of stiffener webs, NODWEB
        5       $ Number of nodes over width of stringer flange, NDFLGS
        5       $ Number of nodes over width of ring flange, NDFLGR
     n          $ Do you want stringer(s) with a high nodal point density?
     n          $ Do you want ring(s) with a high nodal point density?
     n          $ Is there plasticity in this STAGS model?
     y          $ Do you want to use the "least-squares" model for torque?
     n          $ Is stiffener sidesway permitted at the panel edges?
     y          $ Do you want symmetry conditions along the straight edges?
        0       $ Edges parallel to screen (0) in-plane deformable; (1) rigid
        0       $ Stringer web axial displacement index, IBCX0XL=0 or 1
-------------- end of the cylstif.STG file --------------------------
```

The STAGS index, ILIN, is set equal to unity, that is:

```
         1      $ Nonlinear (0) or linear (1) kinematic relations?, ILIN
```

in order to filter out unwanted buckling eigenvalues that correspond to local deformation of the stringers with little or no participation the panel skin.

It is difficult to find the critical "inter-ring" buckling mode from STAGS because that mode is "hidden" within a cluster of stringer buckling modes.

The following is a series of STAGS runs, for which there are two purposes:

1. Obtain the critical (lowest) buckling load factor for the sub-domain model with 6 x 3 bays with both T-stringers and T-rings modeled as flexible shell segments (shell units) and plot the mode shape. See the plot represented by the file, 22.cylstif.stagsunit.6x3.eig1.png. This is local buckling, essentially the same buckling load factor and mode shape computed by PANDA2 (eigenvalue = 1.195; see the plot represented by the file, 3.cylstif.localbuck.panel.png) and by BIGBOSOR4 (eigenvalue = 1.21; see the plot represented by the same file, 3.cylstif.localbuck.panel.png)

2. Search for and find the lowest buckling load factor and mode shape

that correspond to inter-ring buckling, that is, a buckling mode shape that is analogous to that plotted for the 6 x 3 bay model in which the stringers are smeared. (See the plot in the file: 21.cylstif.stagsunit.6x3.smrstr.eig5.png; eigenvalue=2.035.) The "inter-ring" buckling eigenvalue for the more elaborate STAGS model in which the stringers are modeled as flexible shell units was found. The mode shape is represented by the two files, 23.cylstif.stagsunit.6x3.eig43.png and 24.cylstif.stagsunit.6x3.eig43.skin.png; (43rd eigenvalue = 1.91). From STAGS we find that there is only a 6 per cent decrease in the predicted buckling load factor for inter-ring buckling when we go from a model in which the stringers are smeared (eigenvalue = 2.035) to a model in which the stringers are modeled as flexible shell segments (eigenvalue = 1.91). Therefore, in this particular case PANDA2's prediction of inter-ring buckling is conservative when the "conservativeness" index, ICONSV = 1, which is the recommended value of ICONSV. The inter-ring buckling mode found from BIGBOSOR4 is represented by the file, 6.cylstif.interring.panel2.png, and the corresponding buckling load factor from BIGBOSOR4 is 2.338. PANDA2 obtains an inter-ring buckling load factor of 2.03 before knockdown for smeared stringers and a bit more than half that after knockdown for smeared stringers when ICONSV = 1. (knockdown factor, SMRFAC= 5.7026E-01 when ICONSV = 1; SMRFAC = 1.0 when ICONSV = 0 or -1).

The series of 16 STAGS runs that were required to find the inter-ring buckling load factor and mode shape from STAGS are listed next. The input datum, "eigenvalue shift", occurs near the end of the cylstif.bin file. This input datum is changed before each of the STAGS runs is executed. The fragments listed below are from the STAGS output files, cylstif.out2. A column headed "ROOT" has been added in most cases. That column is not included in the regular STAGS output.

The "inter-ring" buckling mode is found after many successive executions of STAGS in which the eigenvalue shift is changed from execution to execution.

cylstif.out2 from STAGS run 1, eigenvalue shift = 1.0:

```
 CONVERGENCE HAS BEEN OBTAINED FOR EIGENVALUES  1 THROUGH   8
                    CRITICAL LOAD FACTOR COMBINATION
   NO.    EIGENVALUE   LOAD SYSTEM A  LOAD SYSTEM B    @DOF
     1   1.127122E+00   1.127122E+00   0.000000E+00   21197 <--critical buckling;
stringers
     2   1.140843E+00   1.140843E+00   0.000000E+00   18553
     3   1.151226E+00   1.151226E+00   0.000000E+00   20429
     4   1.155305E+00   1.155305E+00   0.000000E+00   17785
     5   1.156392E+00   1.156392E+00   0.000000E+00   21197
     6   1.161864E+00   1.161864E+00   0.000000E+00   13265
     7   1.161865E+00   1.161865E+00   0.000000E+00   29129
     8   1.211805E+00   1.211805E+00   0.000000E+00   20381
```

cylstif.out2 from STAGS run 2, eigenvalue shift = 1.25, 10 roots skipped:

```
 CONVERGENCE HAS BEEN OBTAINED FOR EIGENVALUES  1 THROUGH   8
                    CRITICAL LOAD FACTOR COMBINATION
   NO.    EIGENVALUE   LOAD SYSTEM A  LOAD SYSTEM B    @DOF ROOT
     1   1.211805E+00   1.211805E+00   0.000000E+00   20381  8
     2   1.236041E+00   1.236041E+00   0.000000E+00   23025  9
     3   1.249418E+00   1.249418E+00   0.000000E+00   20381 10
     4   1.253260E+00   1.253260E+00   0.000000E+00   17737 11
     5   1.254130E+00   1.254130E+00   0.000000E+00   20381 12
```

```
     6   1.258708E+00   1.258708E+00   0.000000E+00   12449 13
     7   1.258708E+00   1.258708E+00   0.000000E+00   28313 14
     8   1.324552E+00   1.324552E+00   0.000000E+00   20813 15
```

cylstif.out2 from STAGS run 3, eigenvalue shift = 1.35, 15 roots skipped:

```
 CONVERGENCE HAS BEEN OBTAINED FOR EIGENVALUES  1 THROUGH   8
                    CRITICAL LOAD FACTOR COMBINATION
   NO.    EIGENVALUE   LOAD SYSTEM A  LOAD SYSTEM B    @DOF ROOT
     1   1.249418E+00   1.249418E+00   0.000000E+00   26533 10
     2   1.253260E+00   1.253260E+00   0.000000E+00   23025 11
     3   1.254130E+00   1.254130E+00   0.000000E+00   21245 12
     4   1.258708E+00   1.258708E+00   0.000000E+00   29177 13
     5   1.258708E+00   1.258708E+00   0.000000E+00   12449 14
     6   1.324550E+00   1.324550E+00   0.000000E+00   20813 15
     7   1.363465E+00   1.363465E+00   0.000000E+00   20453 16
     8   1.378948E+00   1.378948E+00   0.000000E+00   21269 17
```

cylstif.out2 from STAGS run 4, eigenvalue shift = 1.45, 17 roots skipped:

```
MAXIMUM NUMBER OF ITERATIONS
 CONVERGENCE HAS BEEN OBTAINED FOR EIGENVALUES  1 THROUGH   3
 CONVERGENCE CRITERION HAS NOT BEEN SATISFIED FOR EIGENVALUES   4 THROUGH   8
                    CRITICAL LOAD FACTOR COMBINATION
   NO.    EIGENVALUE   LOAD SYSTEM A  LOAD SYSTEM B    @DOF ROOT
     1   1.458930E+00   1.458930E+00   0.000000E+00   16846 18
     2   1.484976E+00   1.484976E+00   0.000000E+00   18409 19
     3   1.501850E+00   1.501850E+00   0.000000E+00   23457 20
     4   1.509602E+00   1.509602E+00   0.000000E+00   21005
     5   1.513893E+00   1.513893E+00   0.000000E+00   26293
     6   1.515067E+00   1.515067E+00   0.000000E+00   18361
     7   1.515148E+00   1.515148E+00   0.000000E+00   15717
     8   1.515550E+00   1.515550E+00   0.000000E+00   21005
```

cylstif.out2 from STAGS run 5, eigenvalue shift = 1.51, 21 roots skipped:

```
 CONVERGENCE HAS BEEN OBTAINED FOR EIGENVALUES  1 THROUGH   8
                    CRITICAL LOAD FACTOR COMBINATION
   NO.    EIGENVALUE   LOAD SYSTEM A  LOAD SYSTEM B    @DOF ROOT
     1   1.501850E+00   1.501850E+00   0.000000E+00   18169 20
     2   1.509599E+00   1.509599E+00   0.000000E+00   21005 21
     3   1.513885E+00   1.513885E+00   0.000000E+00   15717 22
     4   1.515059E+00   1.515059E+00   0.000000E+00   18361 23
     5   1.515067E+00   1.515067E+00   0.000000E+00   25909 24
     6   1.515507E+00   1.515507E+00   0.000000E+00   21005 25
     7   1.519851E+00   1.519851E+00   0.000000E+00   12689 26
     8   1.519851E+00   1.519851E+00   0.000000E+00   28937 27
```

cylstif.out2 from STAGS run 6, eigenvalue shift = 1.53, 27 roots skipped:

```
 CONVERGENCE HAS BEEN OBTAINED FOR EIGENVALUES  1 THROUGH   8
                    CRITICAL LOAD FACTOR COMBINATION
   NO.    EIGENVALUE   LOAD SYSTEM A  LOAD SYSTEM B    @DOF ROOT
     1   1.513885E+00   1.513885E+00   0.000000E+00   15333 22
     2   1.515059E+00   1.515059E+00   0.000000E+00   18361 23
     3   1.515067E+00   1.515067E+00   0.000000E+00   25909 24
     4   1.515507E+00   1.515507E+00   0.000000E+00   21005 25
     5   1.519851E+00   1.519851E+00   0.000000E+00   13073 26
     6   1.519851E+00   1.519851E+00   0.000000E+00   28937 27
     7   1.544794E+00   1.544794E+00   0.000000E+00   15525 28
```

```
     8   1.549722E+00   1.549722E+00   0.000000E+00   23457 29
```

cylstif.out2 from STAGS run 7, eigenvalue shift = 1.57, 33 roots skipped:

```
MAXIMUM NUMBER OF ITERATIONS
 CONVERGENCE HAS BEEN OBTAINED FOR EIGENVALUES  1 THROUGH   7
                    CRITICAL LOAD FACTOR COMBINATION
   NO.    EIGENVALUE   LOAD SYSTEM A  LOAD SYSTEM B    @DOF ROOT
     1   1.544794E+00   1.544794E+00   0.000000E+00   15525 28
     2   1.549722E+00   1.549722E+00   0.000000E+00   18169 29
     3   1.550753E+00   1.550753E+00   0.000000E+00   20813 30
     4   1.557151E+00   1.557151E+00   0.000000E+00   12881 31
     5   1.557151E+00   1.557151E+00   0.000000E+00   28745 32
     6   1.566488E+00   1.566488E+00   0.000000E+00   20813 33
     7   1.613298E+00   1.613298E+00   0.000000E+00   24766 34
```

cylstif.out2 from STAGS run 8, eigenvalue shift = 1.63, 34 roots skipped:

```
MAXIMUM NUMBER OF ITERATIONS
 CONVERGENCE CRITERION HAS NOT BEEN SATISFIED FOR EIGENVALUES   1 THROUGH   8
                    CRITICAL LOAD FACTOR COMBINATION
   NO.    EIGENVALUE   LOAD SYSTEM A  LOAD SYSTEM B    @DOF ROOT
     1   1.544794E+00   1.544794E+00   0.000000E+00   26101 28
     2   1.549722E+00   1.549722E+00   0.000000E+00   26101 29
     3   1.550752E+00   1.550752E+00   0.000000E+00   20813 30
     4   1.557150E+00   1.557150E+00   0.000000E+00   12881 31
     5   1.557151E+00   1.557151E+00   0.000000E+00   28745 32
     6   1.566488E+00   1.566488E+00   0.000000E+00   20813 33
     7   1.613298E+00   1.613298E+00   0.000000E+00   27416 34
     8   1.617841E+00   1.617841E+00   0.000000E+00   12449 ??
```

cylstif.out2 from STAGS run 9, eigenvalue shift = 1.65, 34 roots skipped:

```
MAXIMUM NUMBER OF ITERATIONS
 CONVERGENCE CRITERION HAS NOT BEEN SATISFIED FOR EIGENVALUES   1 THROUGH   8
                    CRITICAL LOAD FACTOR COMBINATION
   NO.    EIGENVALUE   LOAD SYSTEM A  LOAD SYSTEM B    @DOF ROOT
     1   1.549721E+00   1.549721E+00   0.000000E+00   18169
     2   1.550734E+00   1.550734E+00   0.000000E+00   20813
     3   1.557141E+00   1.557141E+00   0.000000E+00   28745
     4   1.557148E+00   1.557148E+00   0.000000E+00   12881
     5   1.566487E+00   1.566487E+00   0.000000E+00   20813
     6   1.613298E+00   1.613298E+00   0.000000E+00   27416
     7   1.685983E+00   1.685983E+00   0.000000E+00   23265
     8   1.717634E+00   1.717634E+00   0.000000E+00   20375
```

cylstif.out2 from STAGS run 10, eigenvalue shift = 1.71, 34 roots skipped:

```
MAXIMUM NUMBER OF ITERATIONS
 CONVERGENCE CRITERION HAS NOT BEEN SATISFIED FOR EIGENVALUES   1 THROUGH   8
                    CRITICAL LOAD FACTOR COMBINATION
   NO.    EIGENVALUE   LOAD SYSTEM A  LOAD SYSTEM B    @DOF
     1   1.549760E+00   1.549760E+00   0.000000E+00   23481
     2   1.550656E+00   1.550656E+00   0.000000E+00   20813
     3   1.557145E+00   1.557145E+00   0.000000E+00   28745
     4   1.557303E+00   1.557303E+00   0.000000E+00   12881
     5   1.566482E+00   1.566482E+00   0.000000E+00   20813
     6   1.613298E+00   1.613298E+00   0.000000E+00   24766
     7   1.715446E+00   1.715446E+00   0.000000E+00   25861
     8   1.744187E+00   1.744187E+00   0.000000E+00   13001
```

cylstif.out2 from STAGS run 11, eigenvalue shift = 1.76, 34 roots skipped:

```
MAXIMUM NUMBER OF ITERATIONS
 CONVERGENCE CRITERION HAS NOT BEEN SATISFIED FOR EIGENVALUES   1 THROUGH   8
                    CRITICAL LOAD FACTOR COMBINATION
   NO.    EIGENVALUE   LOAD SYSTEM A  LOAD SYSTEM B    @DOF
     1   1.676389E+00   1.676389E+00   0.000000E+00   20789
     2   1.700713E+00   1.700713E+00   0.000000E+00   12953
     3   1.762175E+00   1.762175E+00   0.000000E+00   12905
     4   1.871755E+00   1.871755E+00   0.000000E+00   15525
     5   1.887114E+00   1.887114E+00   0.000000E+00   20813
     6   1.890529E+00   1.890529E+00   0.000000E+00   18169
     7   1.891057E+00   1.891057E+00   0.000000E+00   20813
     8   1.891468E+00   1.891468E+00   0.000000E+00   15525
```

cylstif.out2 from STAGS run 12, eigenvalue shift = 1.73, 34 roots skipped; 4 eigenvalues sought:

```
MAXIMUM NUMBER OF ITERATIONS
 CONVERGENCE CRITERION HAS NOT BEEN SATISFIED FOR EIGENVALUES   1 THROUGH   3
                    CRITICAL LOAD FACTOR COMBINATION
   NO.    EIGENVALUE   LOAD SYSTEM A  LOAD SYSTEM B    @DOF ROOT
     1   1.613298E+00   1.613298E+00   0.000000E+00   27416 34
     2   1.642475E+00   1.642475E+00   0.000000E+00   26053 ??
     3   1.871754E+00   1.871754E+00   0.000000E+00   26101 35?
```

cylstif.out2 from STAGS run 13, eigenvalue shift = 1.80, 34 roots skipped; 1 eigenvalue sought:

```
 CONVERGENCE HAS BEEN OBTAINED FOR EIGENVALUES  1 THROUGH   1
                    CRITICAL LOAD FACTOR COMBINATION
   NO.    EIGENVALUE   LOAD SYSTEM A  LOAD SYSTEM B    @DOF ROOT
     1   1.871755E+00   1.871755E+00   0.000000E+00   20813 35
```

```
******* NOTE: There is a big eigenvalue "hole" betwee 1.613298 (root 34) and
*******       1.871754 (root 35). Why? Don't know why.
```

cylstif.out2 from STAGS run 14, eigenvalue shift = 1.95, 34 roots skipped; 8 eigenvalues sought:

```
MAXIMUM NUMBER OF ITERATIONS
 CONVERGENCE HAS BEEN OBTAINED FOR EIGENVALUES  1 THROUGH   4
 CONVERGENCE CRITERION HAS NOT BEEN SATISFIED FOR EIGENVALUES   5 THROUGH   8
                    CRITICAL LOAD FACTOR COMBINATION
   NO.    EIGENVALUE   LOAD SYSTEM A  LOAD SYSTEM B    @DOF ROOT
     1   1.925127E+00   1.925127E+00   0.000000E+00   32713 44
     2   1.928869E+00   1.928869E+00   0.000000E+00   34489 45
     3   1.971939E+00   1.971939E+00   0.000000E+00   20399 46
     4   1.982155E+00   1.982155E+00   0.000000E+00   34285 47
     5   1.987382E+00   1.987382E+00   0.000000E+00   34285
     6   1.987598E+00   1.987598E+00   0.000000E+00   15111
     7   1.988930E+00   1.988930E+00   0.000000E+00   26503
     8   1.989121E+00   1.989121E+00   0.000000E+00   21215
```

cylstif.out2 from STAGS run 15, eigenvalue shift = 1.90, 41 roots skipped; 8 eigenvalues sought:

```
 CONVERGENCE HAS BEEN OBTAINED FOR EIGENVALUES  1 THROUGH   8
                    CRITICAL LOAD FACTOR COMBINATION
   NO.    EIGENVALUE   LOAD SYSTEM A  LOAD SYSTEM B    @DOF ROOT
     1   1.886993E+00   1.886993E+00   0.000000E+00   20813 36
     2   1.890303E+00   1.890303E+00   0.000000E+00   15525 37
     3   1.890900E+00   1.890900E+00   0.000000E+00   20813 38
     4   1.891182E+00   1.891182E+00   0.000000E+00   15525 39
     5   1.896987E+00   1.896987E+00   0.000000E+00   12881 40
     6   1.896987E+00   1.896987E+00   0.000000E+00   28745 41
     7   1.904430E+00   1.904430E+00   0.000000E+00   26101 42
     8   1.910033E+00   1.910033E+00   0.000000E+00   10053 43 <--inter-ring buckling
                                                                  mixed with stringer
sidesway
```

cylstif.out2 from STAGS run 16, eigenvalue shift = 2.0, 54 roots skipped; 8 eigenvalues sought:

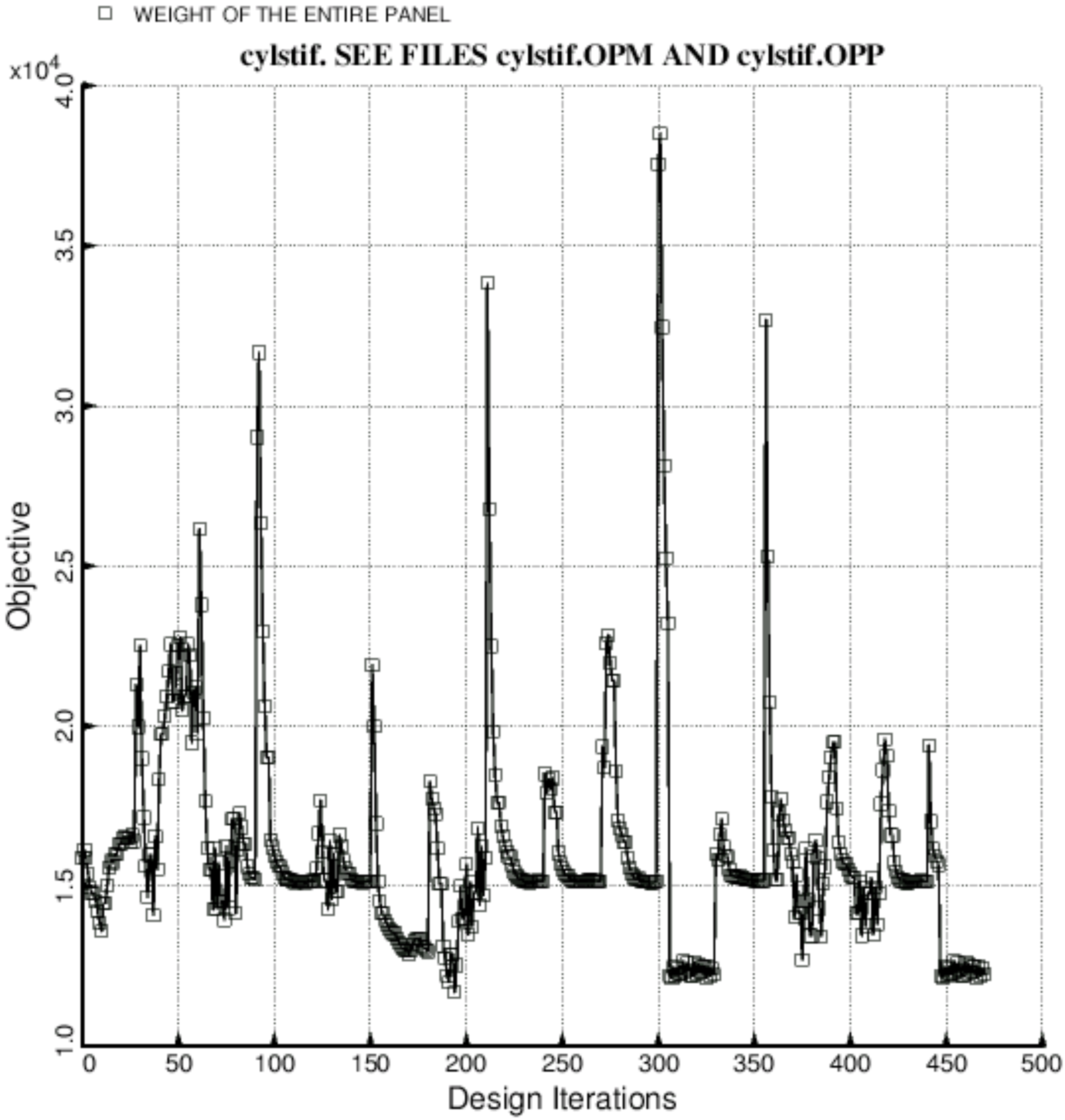
```
 CONVERGENCE HAS BEEN OBTAINED FOR EIGENVALUES  1 THROUGH   8
                    CRITICAL LOAD FACTOR COMBINATION
   NO.    EIGENVALUE   LOAD SYSTEM A  LOAD SYSTEM B    @DOF ROOT
     1   1.987379E+00   1.987379E+00   0.000000E+00   34285 48
     2   1.987534E+00   1.987534E+00   0.000000E+00   18571 49
     3   1.988909E+00   1.988909E+00   0.000000E+00   15927 50
     4   1.988975E+00   1.988975E+00   0.000000E+00   25687 51
     5   1.989196E+00   1.989196E+00   0.000000E+00   20399 52
     6   1.995014E+00   1.995014E+00   0.000000E+00   13283 53
     7   1.995014E+00   1.995014E+00   0.000000E+00   28331 54
     8   2.002111E+00   2.002111E+00   0.000000E+00   21233 55
```

Plots of the inter-ring buckling mode with associated eigenvalue are contained in the two files:

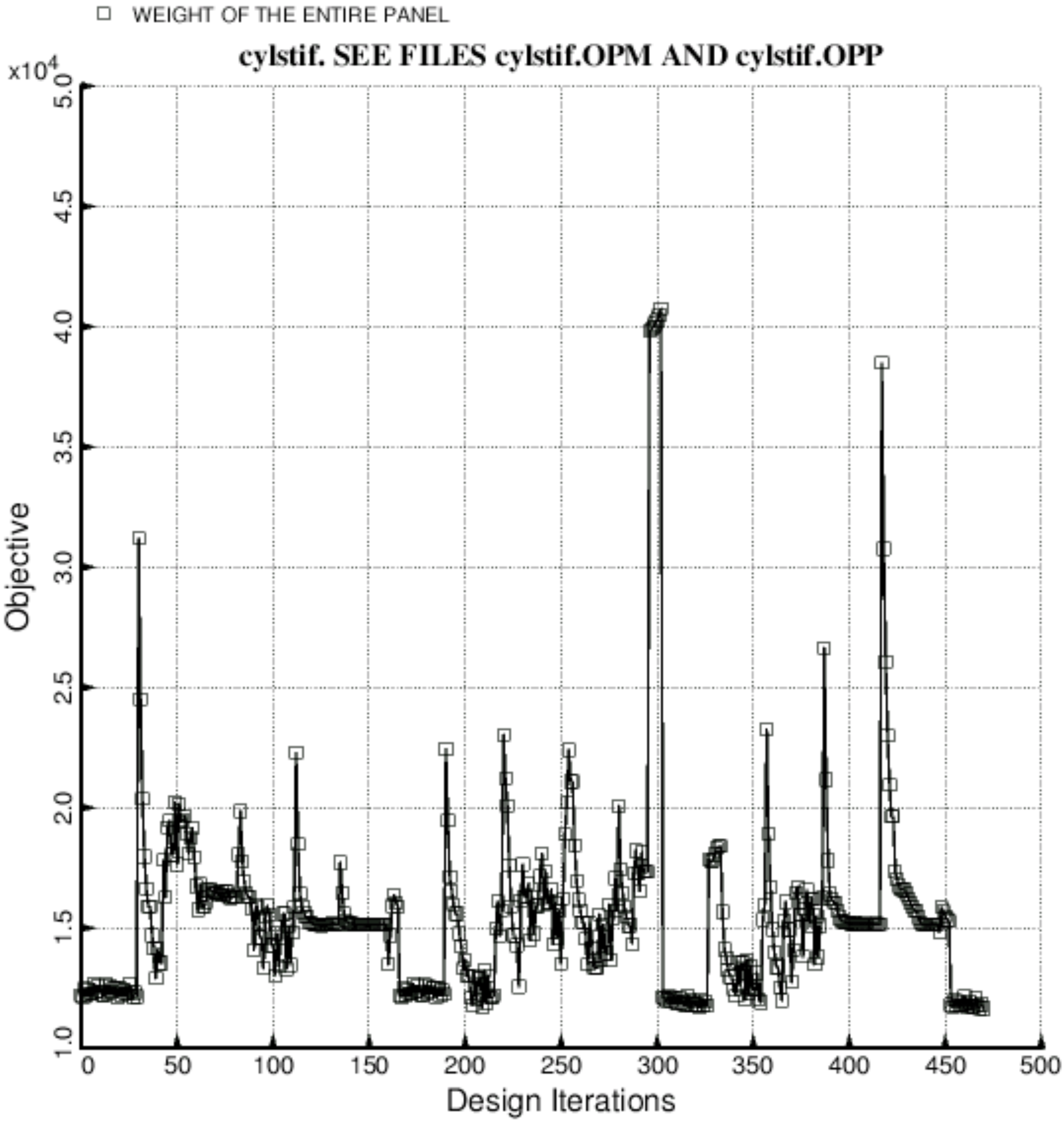
23.cylstif.stagsunit.6x3.eig43.png
24.cylstif.stagsunit.6x3.eig43.skin.png

What is called here the "inter-ring buckling mode" is a mode in which the stringers bend in the axial direction between rings along with the skin, and there are nodal lines in the skin deformation at the axial stations where the web roots of the rings intersect the skin. This 43rd buckling mode is analogous to that from STAGS depicted in the file, 21.cylstif.stagsunit.6x3.smrstr.eig5.png (buckling load factor, eigenvalue=2.035), and that from BIGBOSOR4 depicted in the file, 6.cylstif.interring.panel2.png (buckling load factor, eigenvalue=2.338). The inter-ring buckling load factor from BIGBOSOR4 (2.338) is higher than that from STAGS (2.035) mainly because BIGBOSOR4 does not handle the effects of transverse shear deformation (t.s.d.) and the STAGS 480 finite element does.

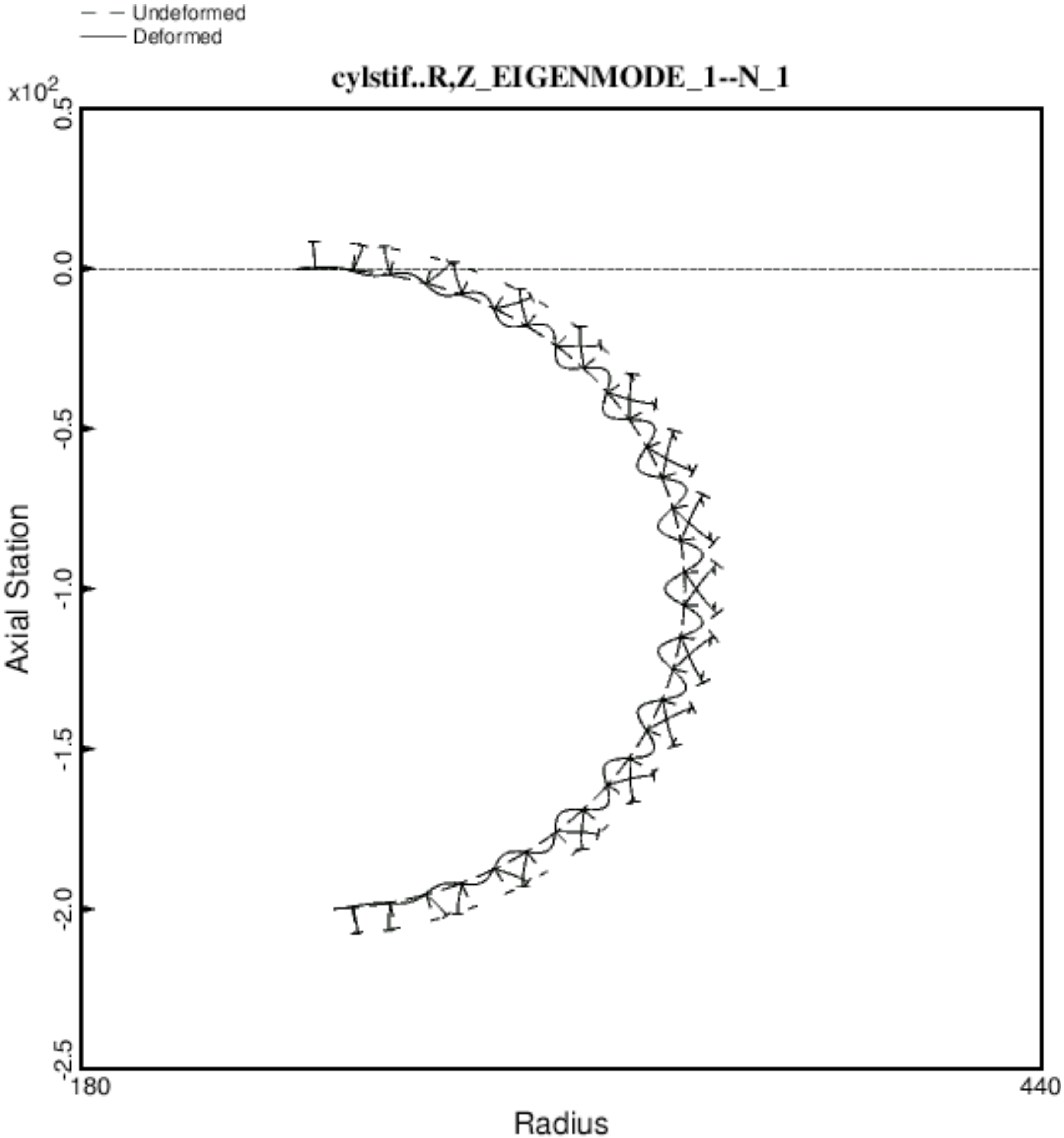
===



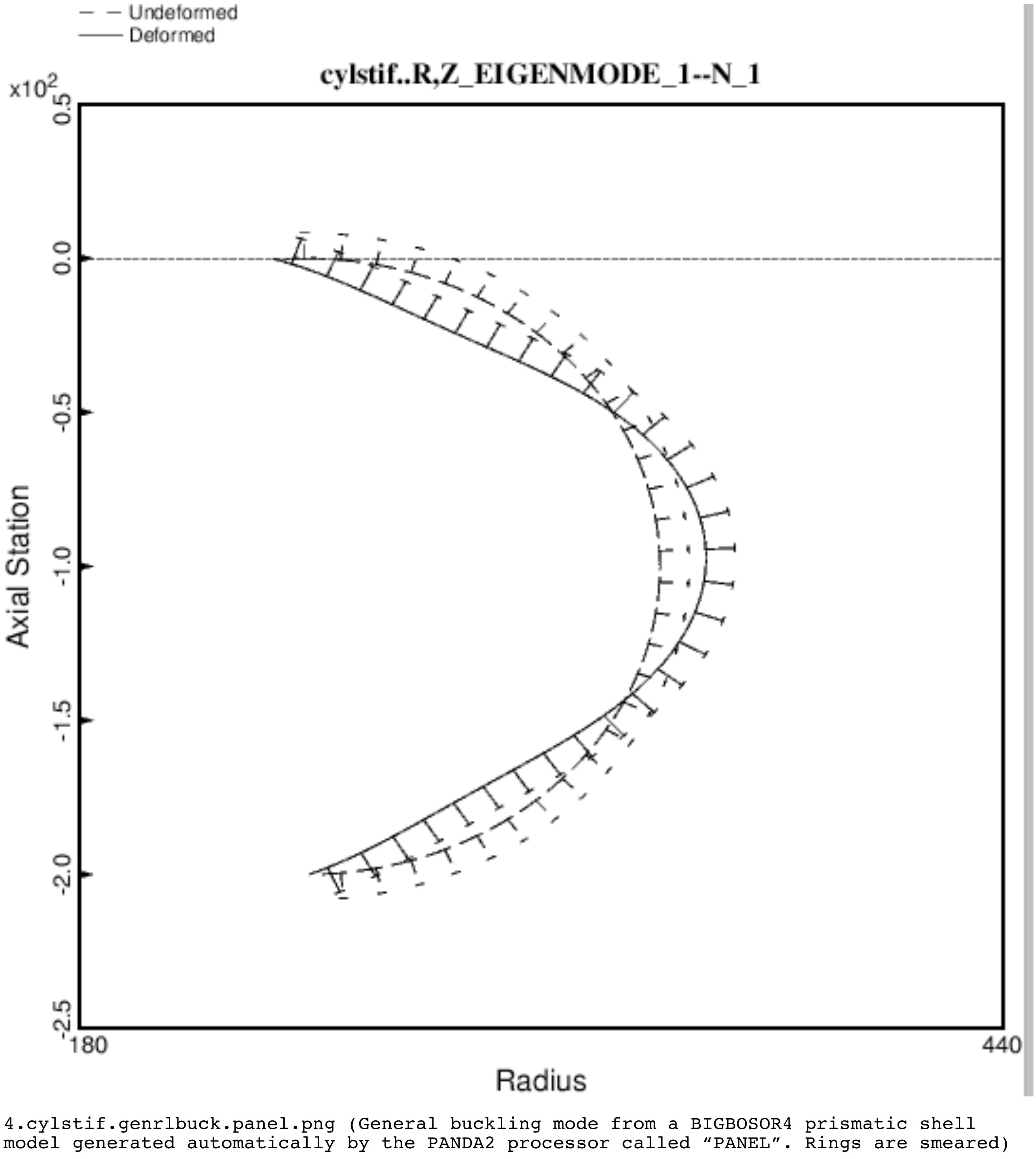
1.cylstif.superopt1.objective.png (PANDA2 results from the first execution of SUPEROPT)



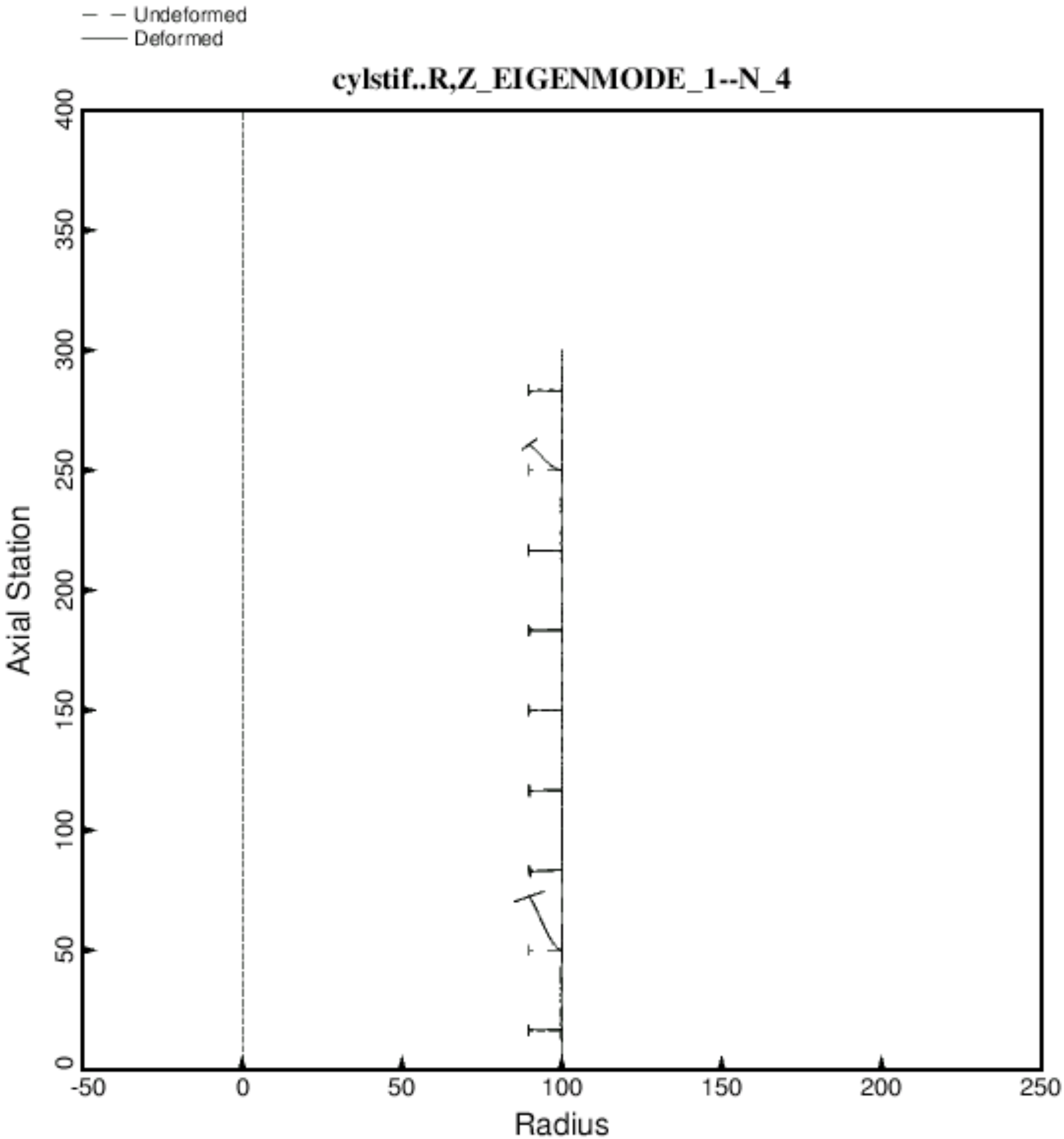
2.cylstif.superopt2.objective.png (PANDA2 results from the 2nd execution of SUPEROPT)



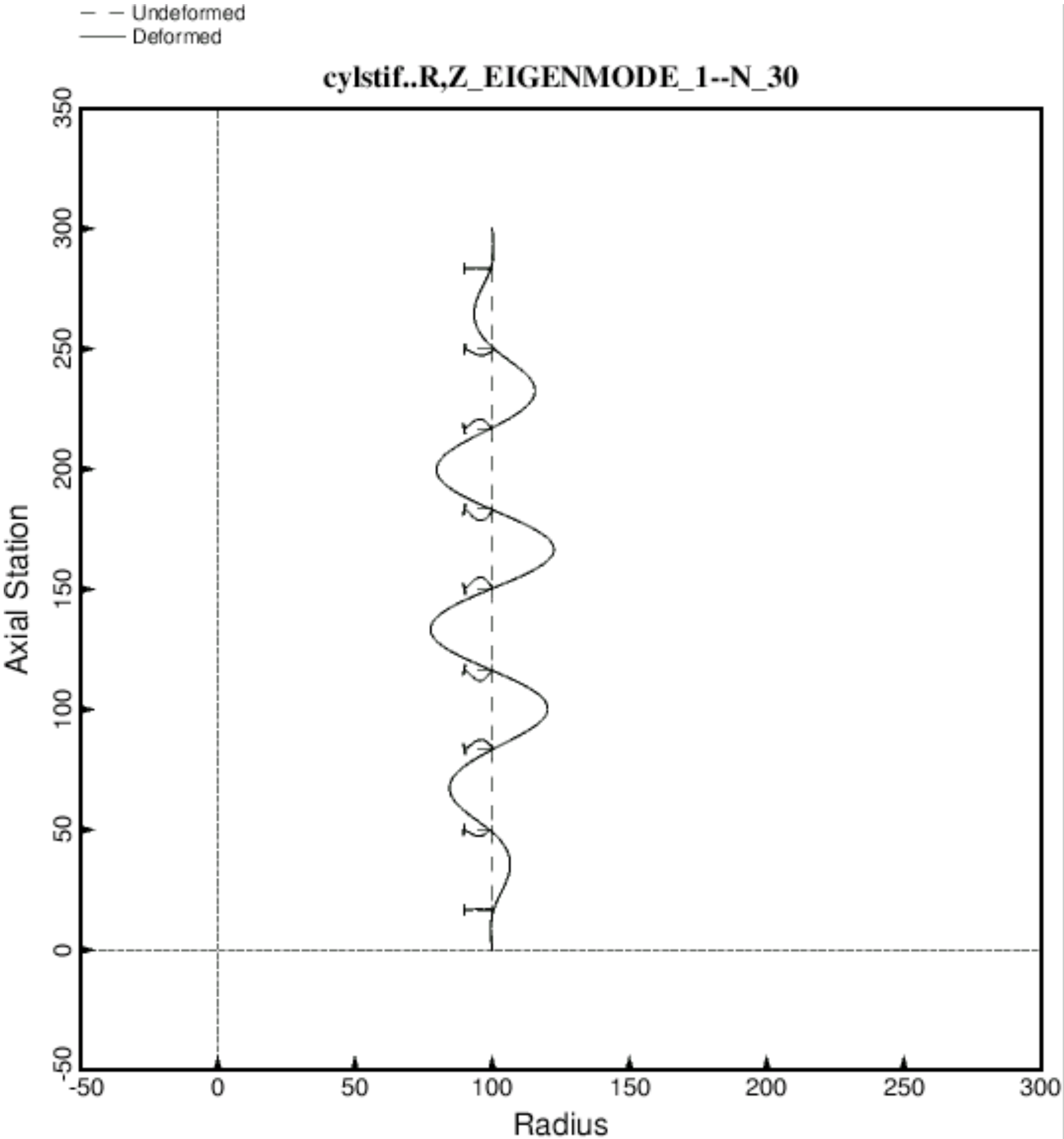
3.cylstif.localbuck.panel.png (Local buckling mode from a BIGBOSOR4 prismatic shell model generated automatically by the PANDA2 processor called "PANEL")



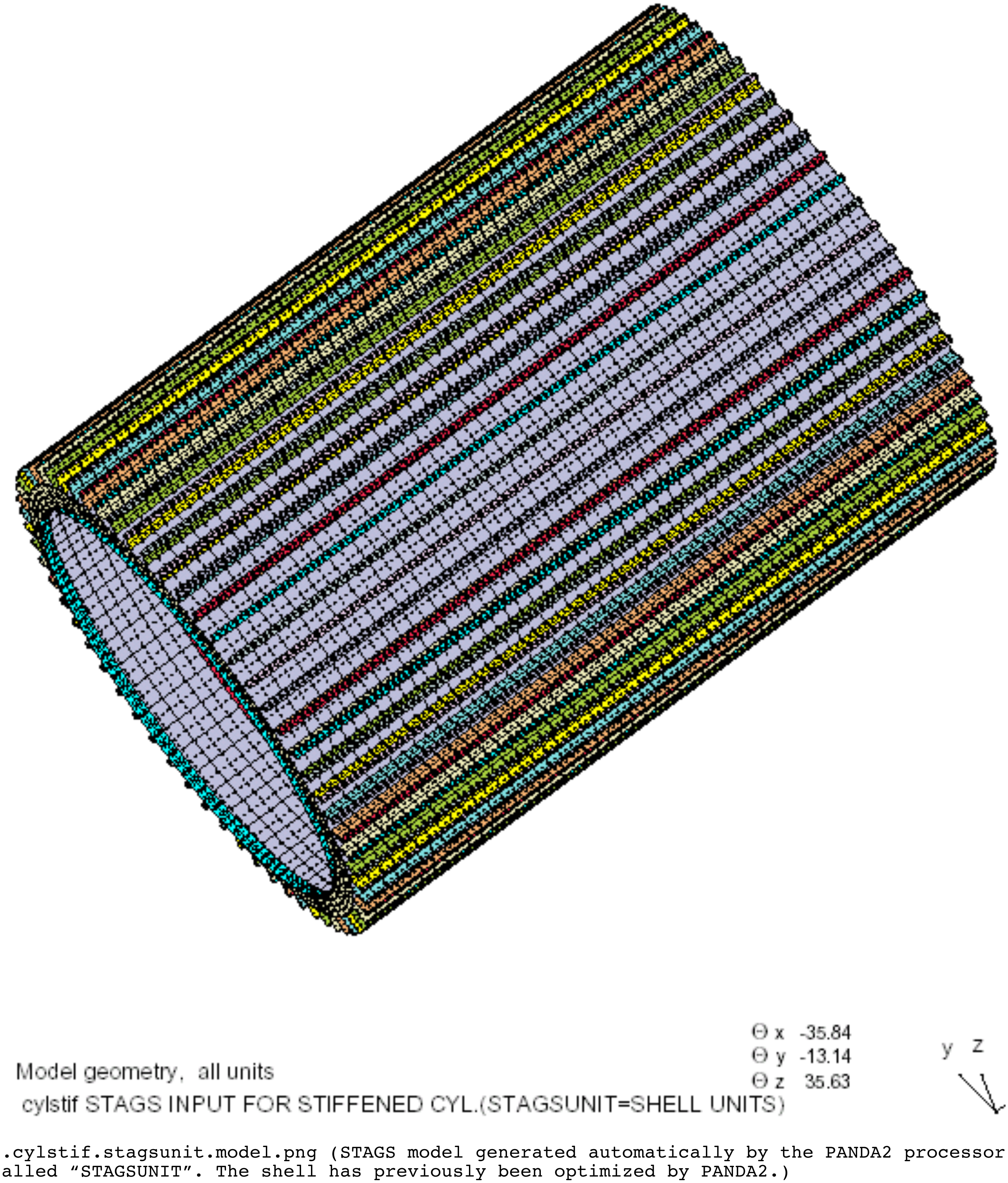
4.cylstif.genrlbuck.panel.png (General buckling mode from a BIGBOSOR4 prismatic shell model generated automatically by the PANDA2 processor called "PANEL". Rings are smeared)



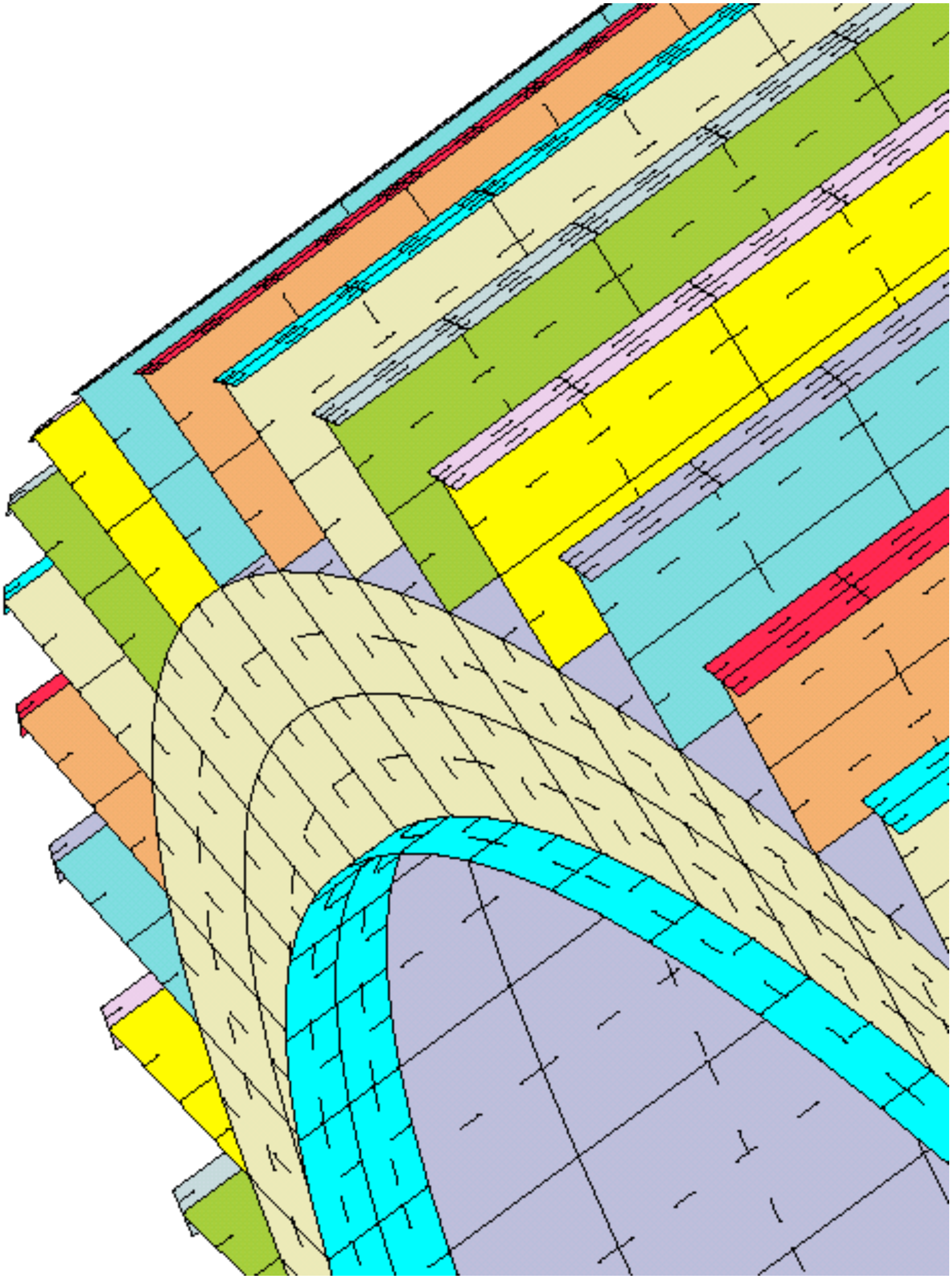
5.cylstif.ringsidesway.panel2.png (Ring sidesway buckling from a BIGBOSOR4 shell-of-revolution model generated automatically by the PANDA2 processor called "PANEL2")



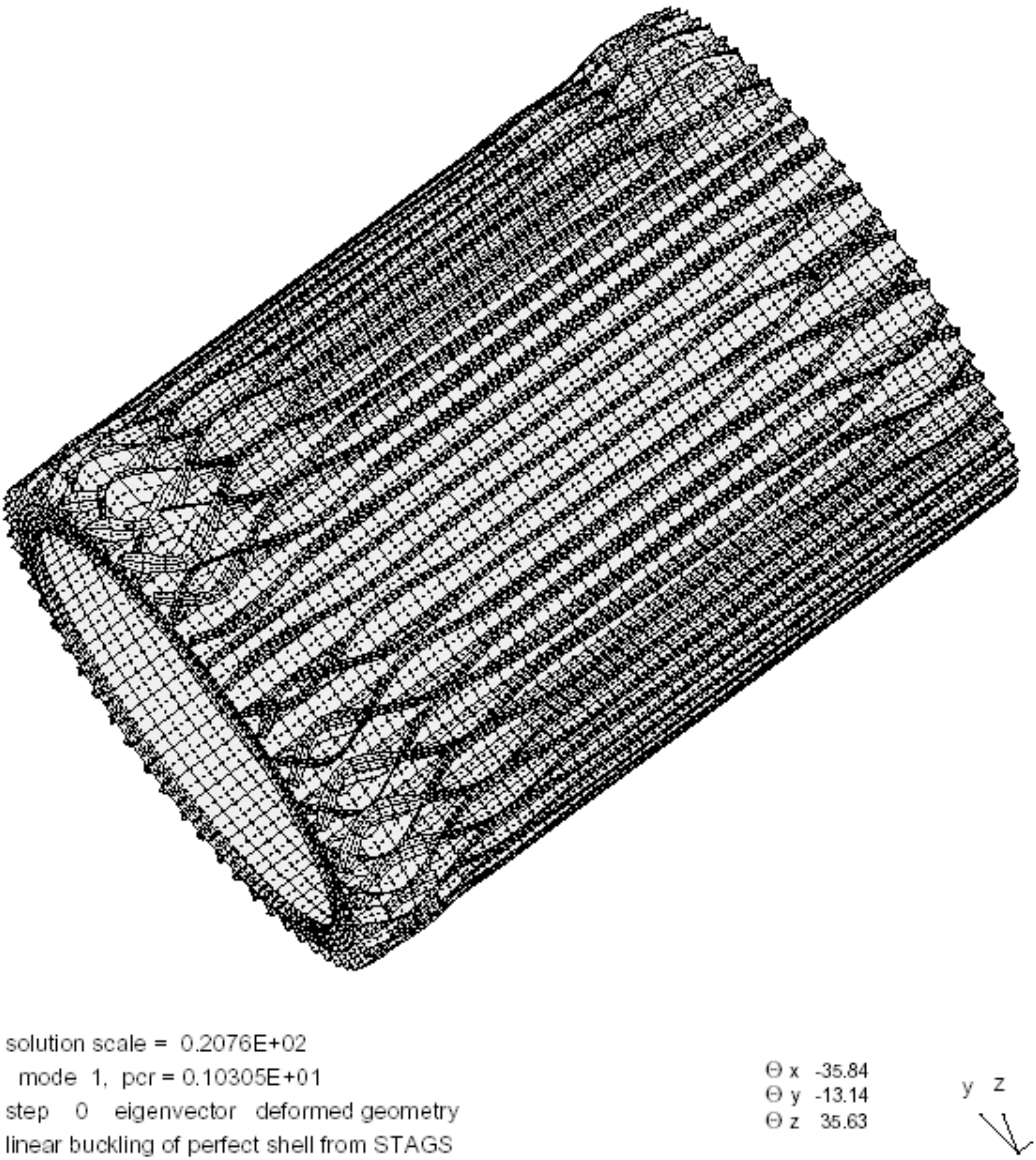
6.cylstif.interring.panel2.png (Inter-ring buckling from a BIGBOSOR4 shell-of-revolution model generated automatically by the PANDA2 processor called "PANEL2")



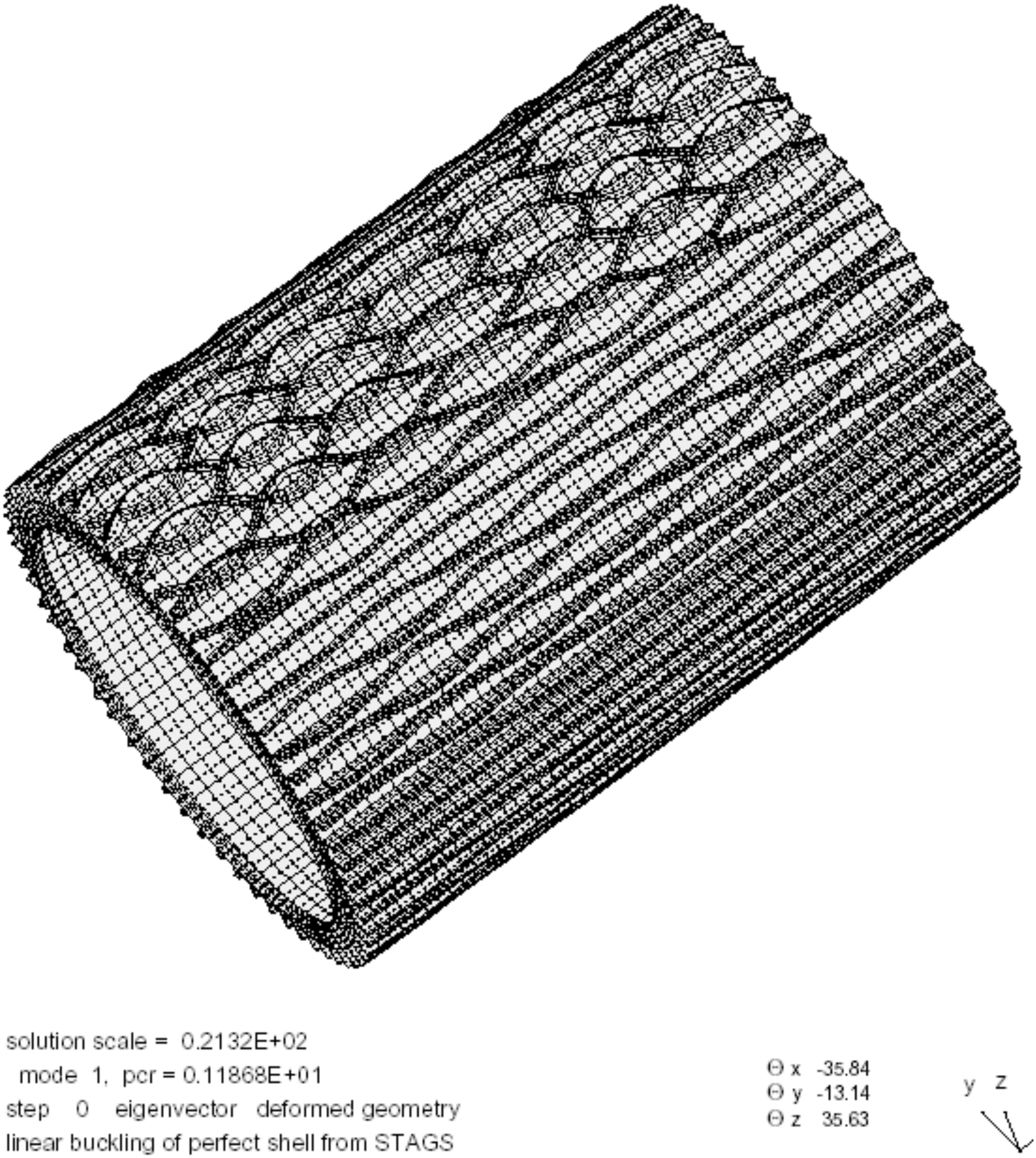
7.cylstif.stagsunit.model.png (STAGS model generated automatically by the PANDA2 processor called "STAGSUNIT". The shell has previously been optimized by PANDA2.)



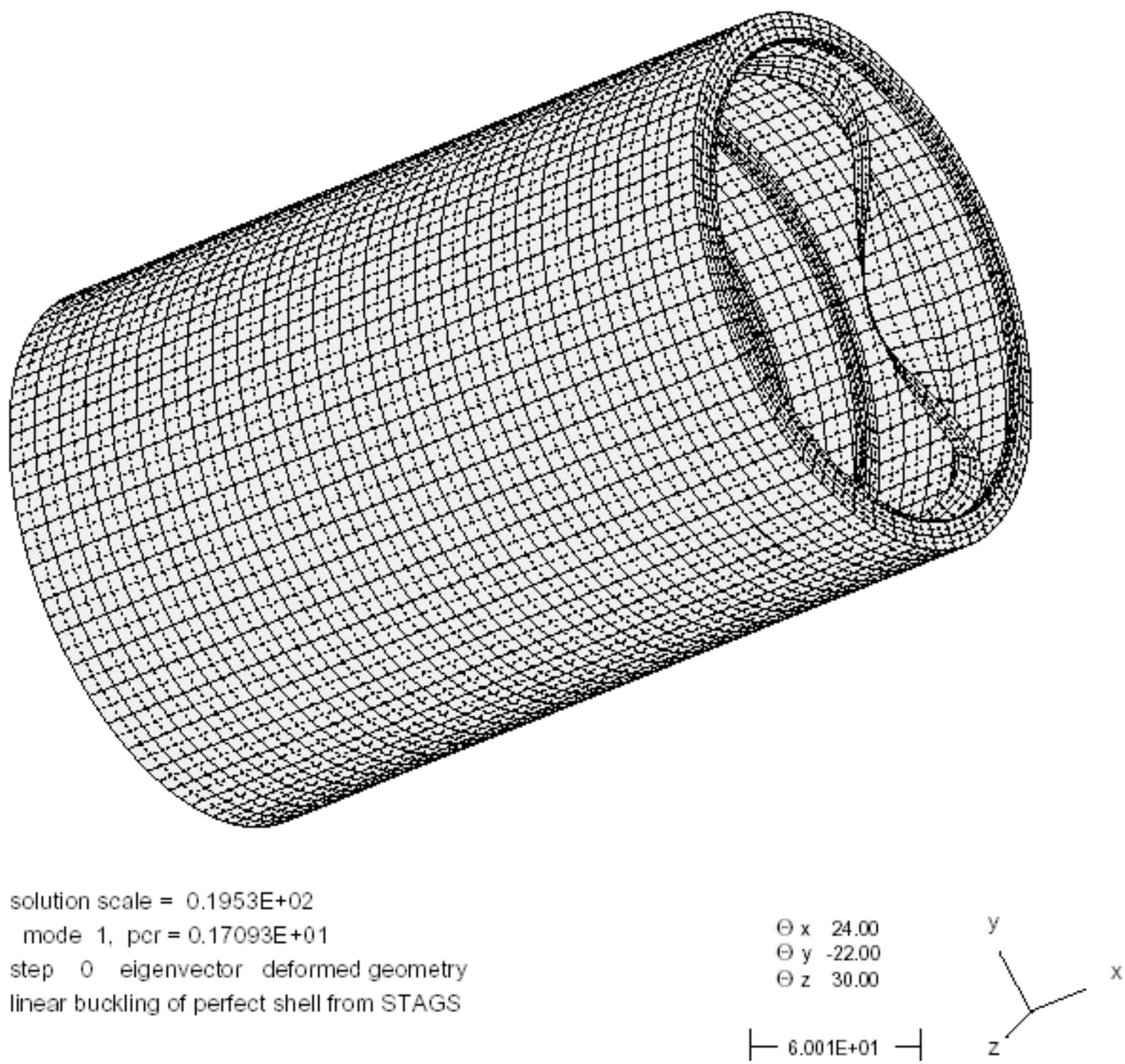
8.cylstif.stagsunit.model.zoom.png (Detail of the same model as that shown in the previous figure.)



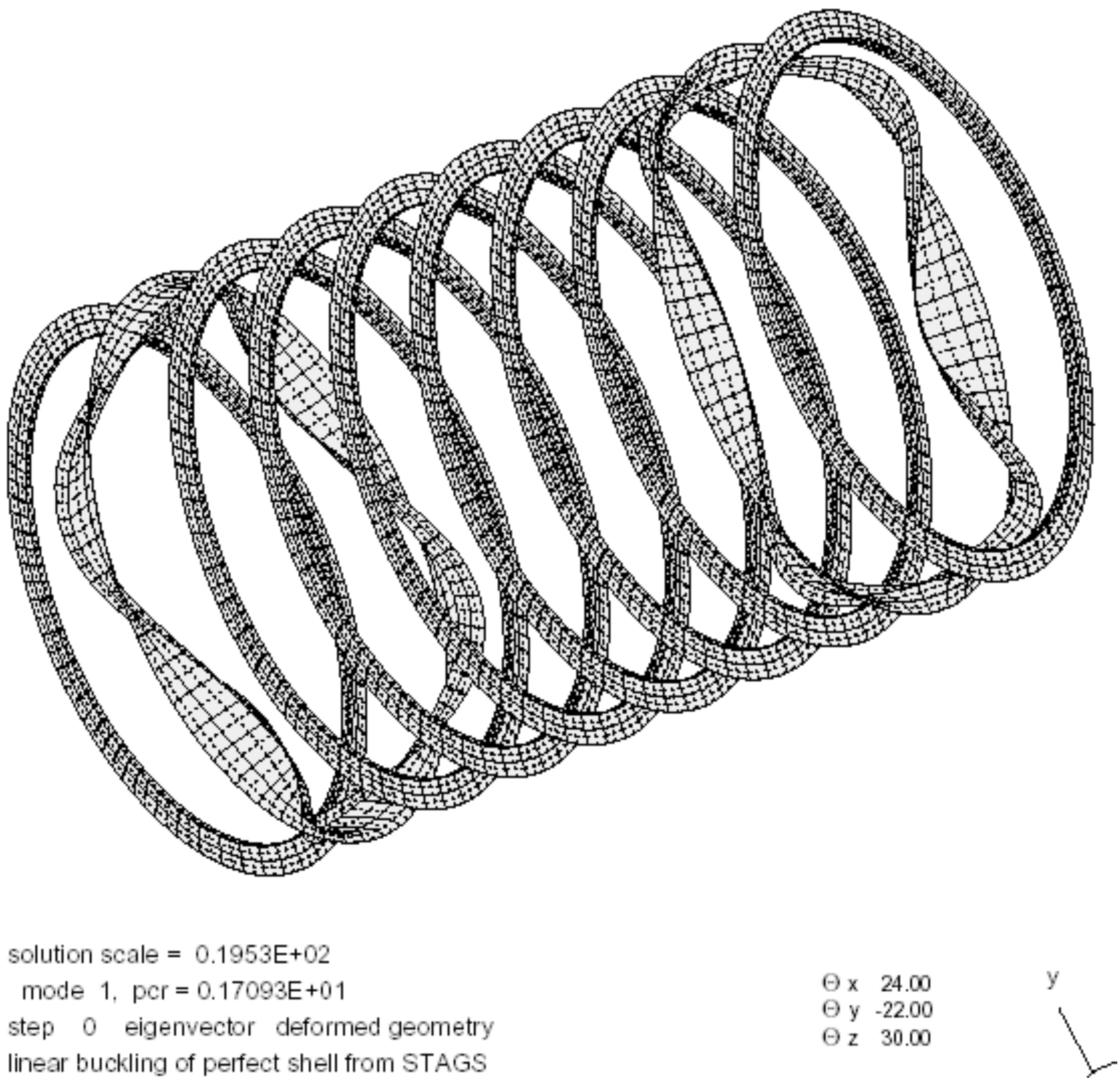
9.cylstif.stagsunit.eig1.png (curved edges can undergo in-plane warping)



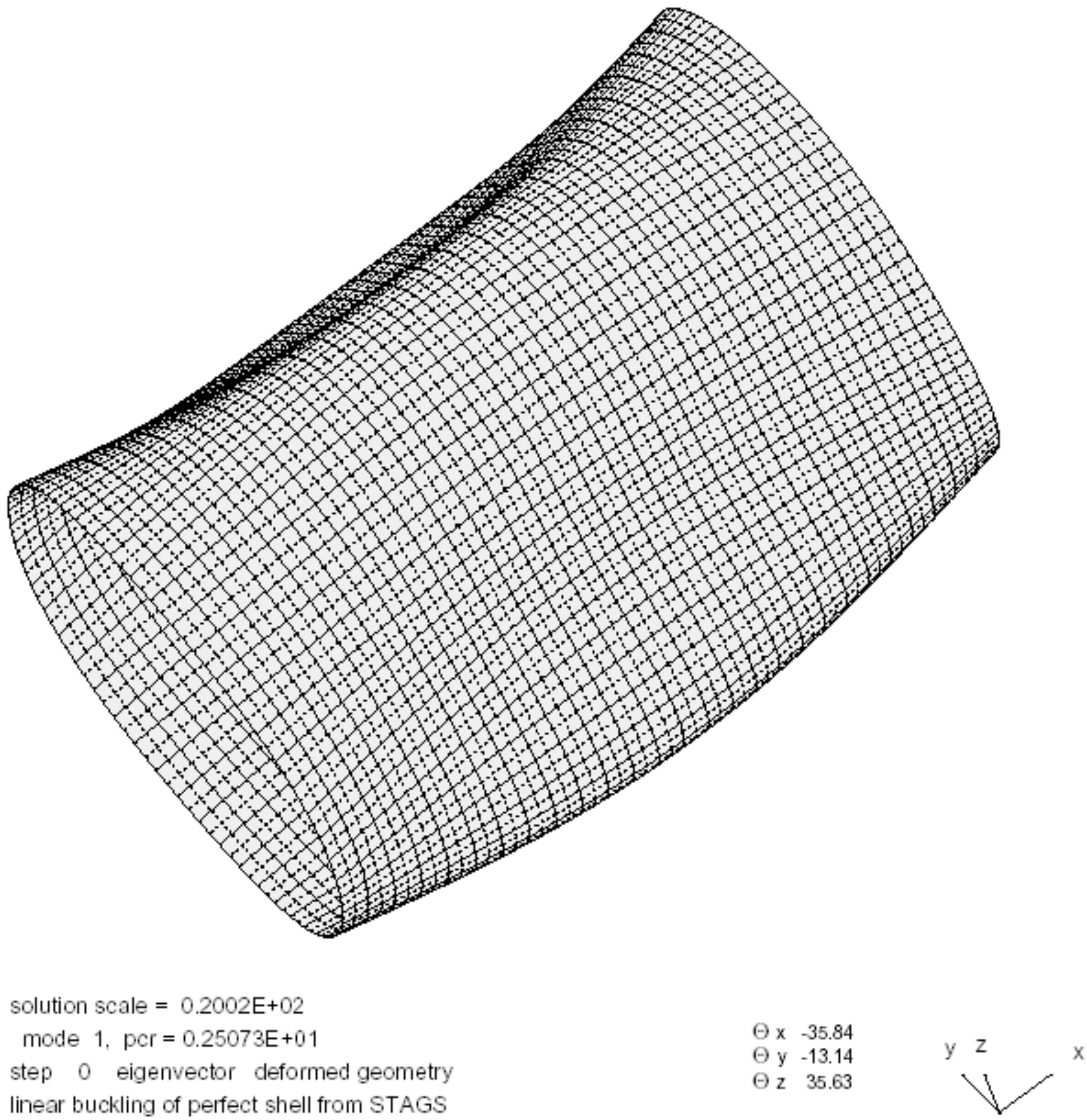
10.cylstif.stagsunit.eig1.rigidends.png (no in-plane warping of the curved edges)



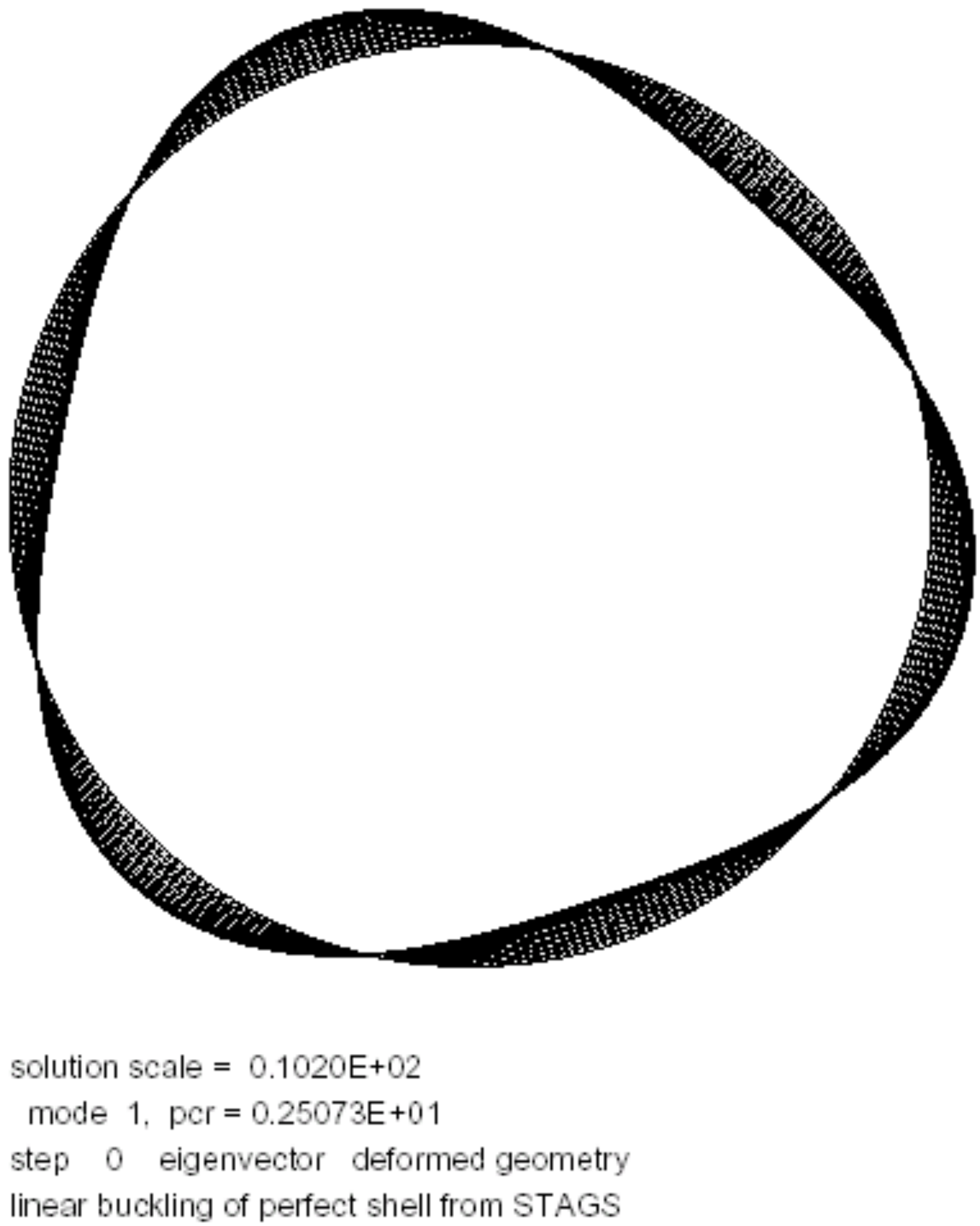
11.cylstif.stagsunit.smrstr.eig1.png (stringers are smeared out)



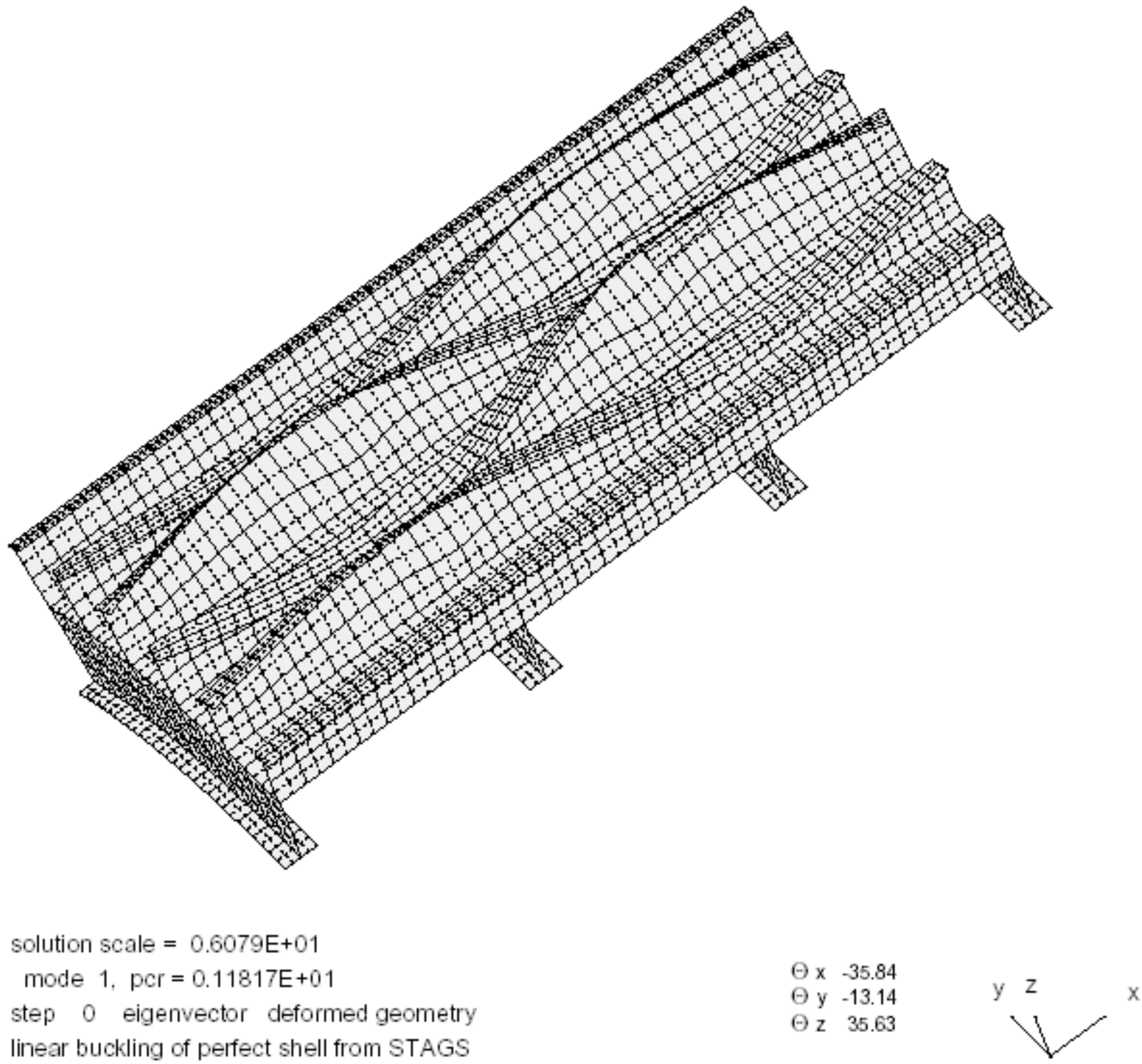
12.cylstif.stagsunit.smrstr.eig1.rngs.png (same as previous except no skin shows)



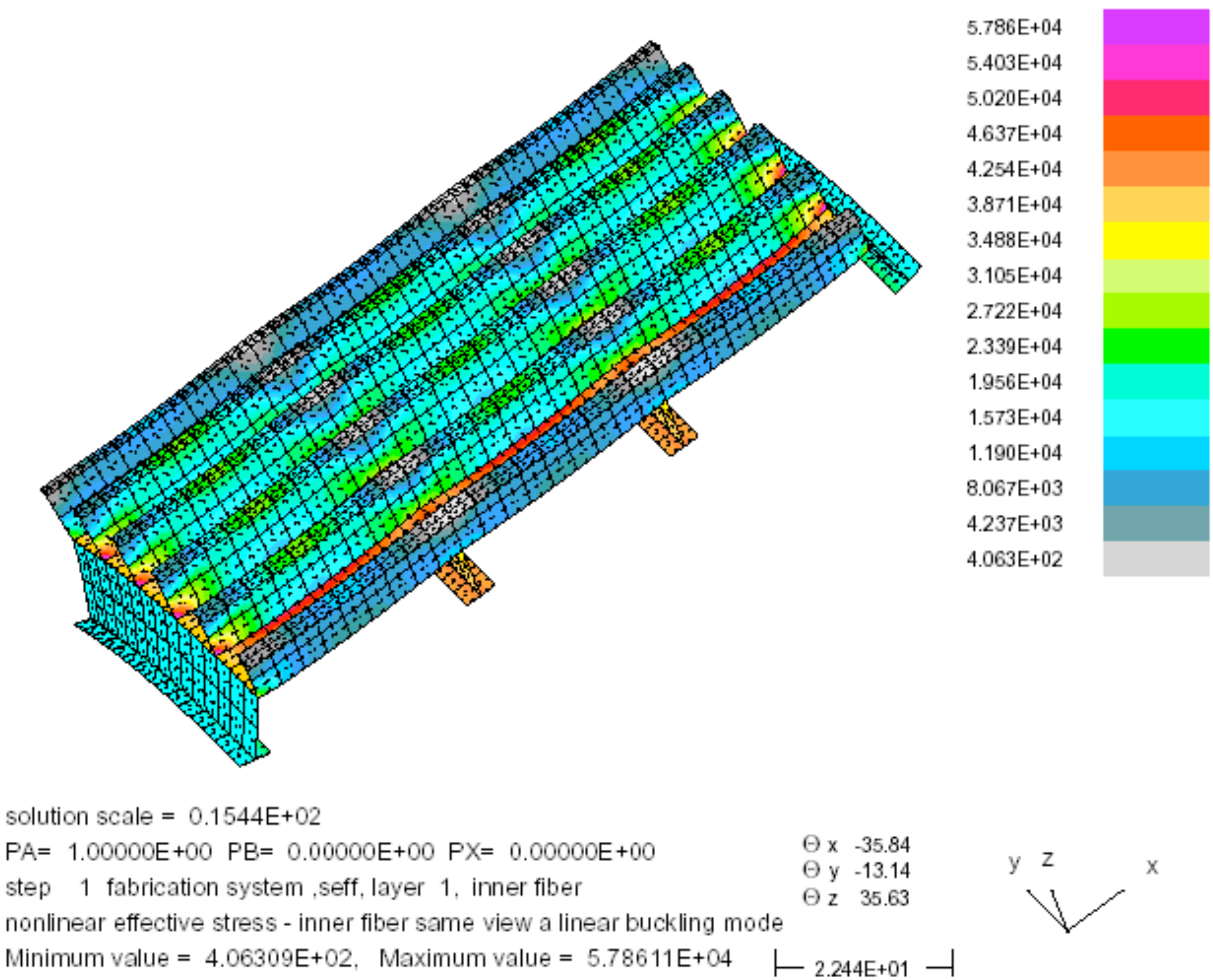
13.cylstif.stagsunit.genbuck.eig1.png (both stringers and rings are smeared out)



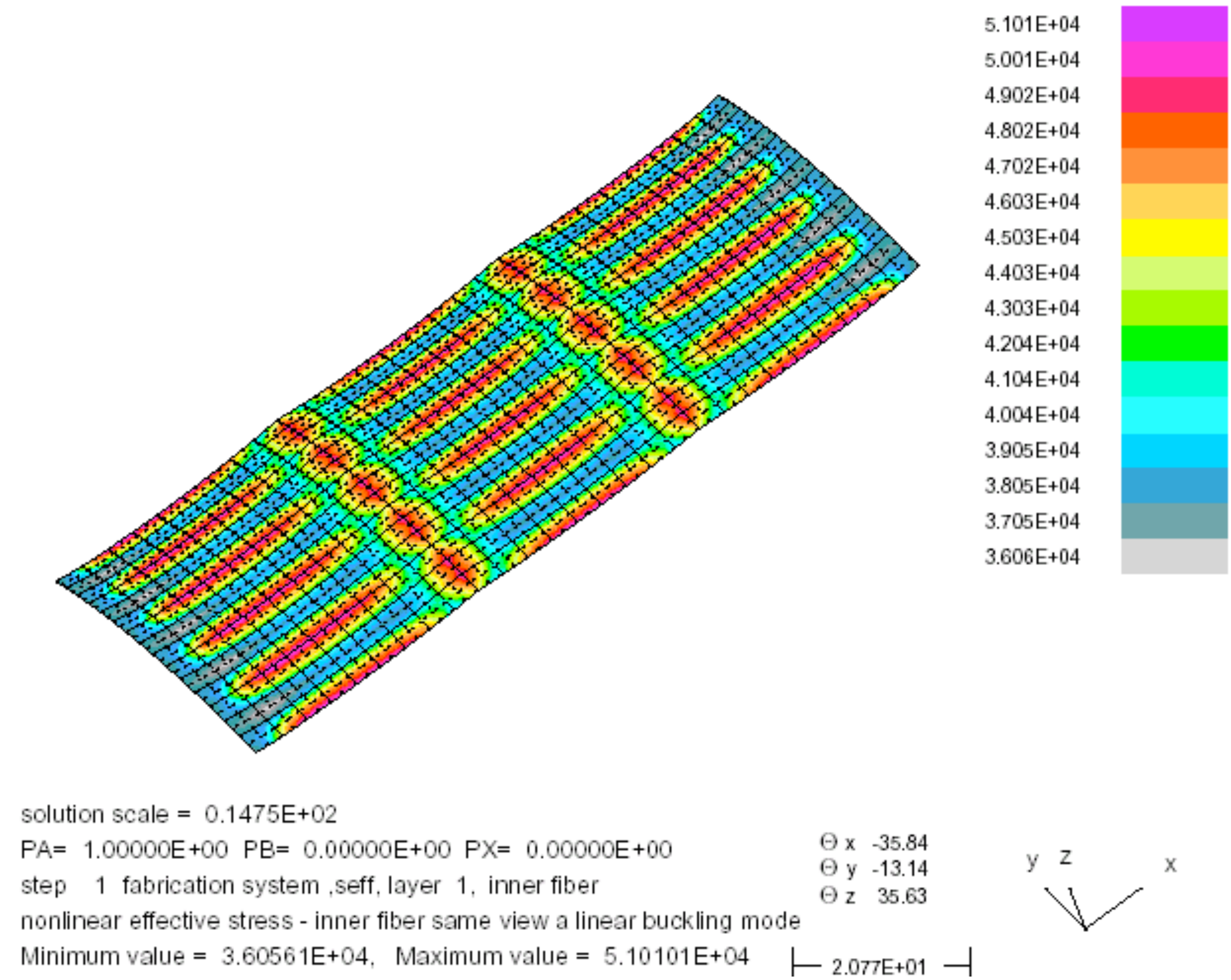
14.cylstif.stagsunit.genbuck.eig1.endview.png (end view of same general buckling mode as that shown in the previous figure. Note that the general buckling mode resembles that from the BIGBOSOR4 model shown in the figure, 4.cylstif.genrlbuck.panel.png)



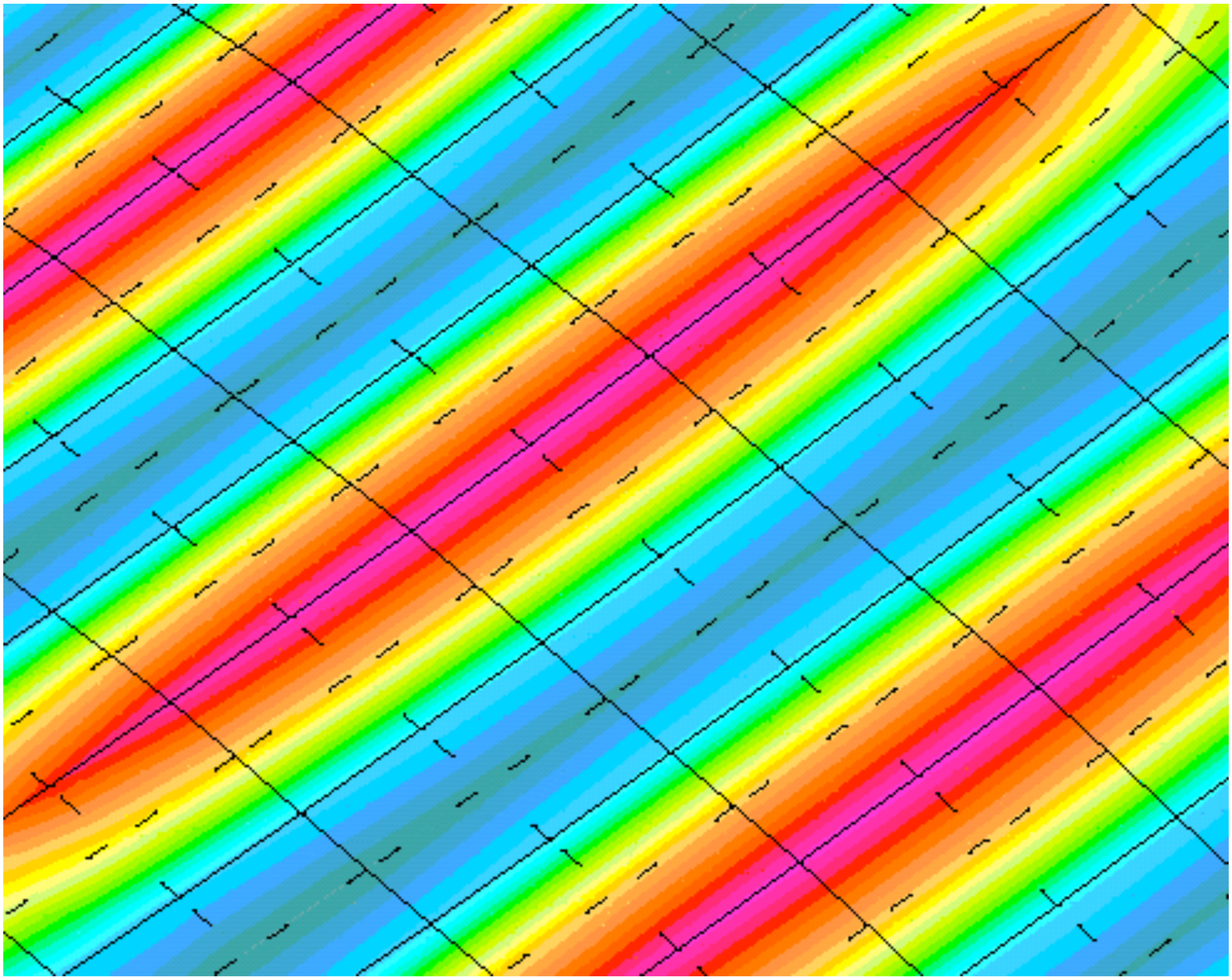
15.cylstif.stagsunit.locbuck.5x3bay.eig1.png (sub-domain model generated automatically by the PANDA2 processor called “STAGSUNIT”. This model captures local buckling. All the stiffener segments are modeled as flexible shell units.)



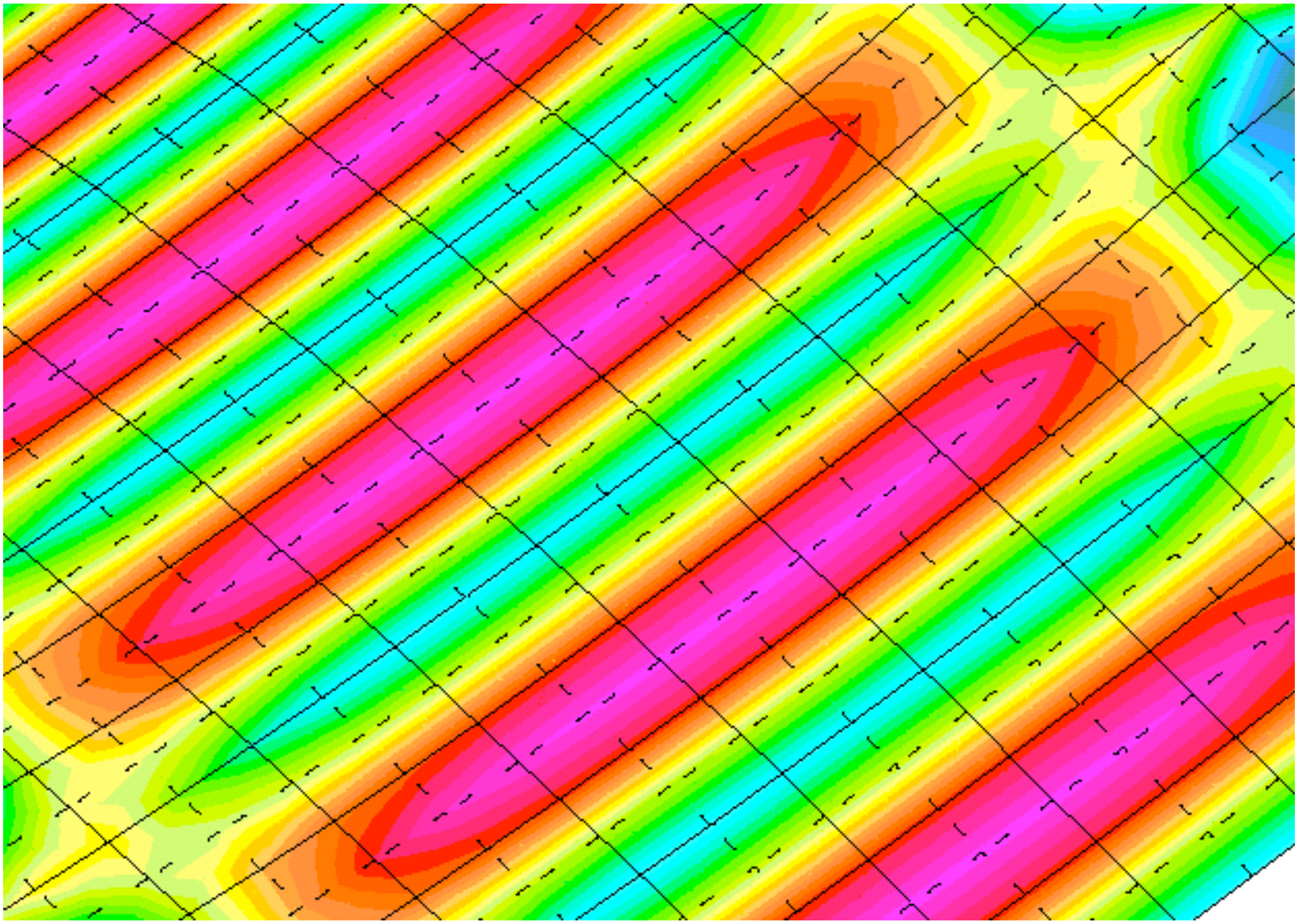
16.cylstif.stagsunit.innerfibstress.5x3.png (inner fiber stress in psi from the 5 stringer bay x 3 ring bay sub-domain model generated automatically by STAGSUNIT.)



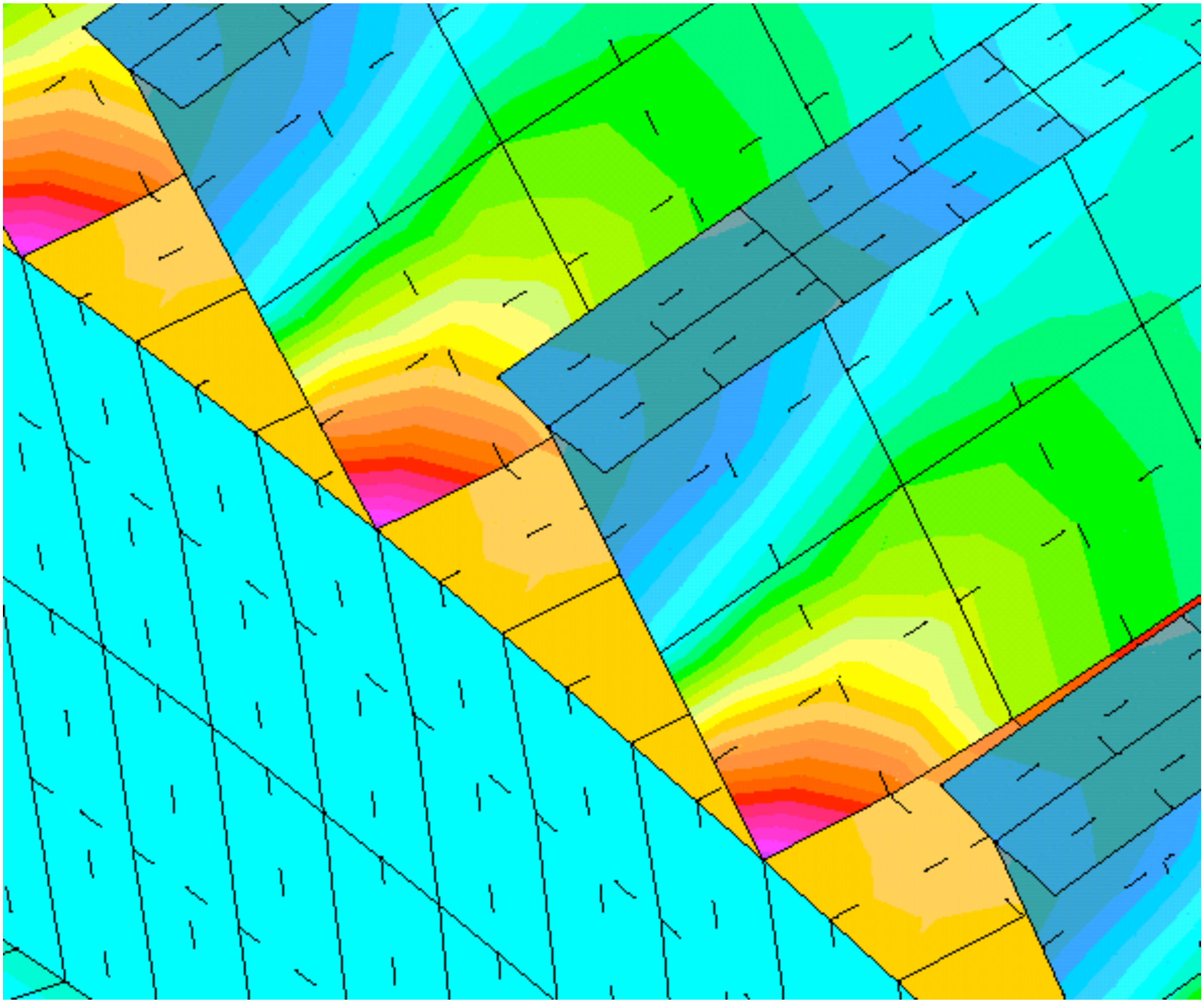
17.cylstif.stagsunit.innerfibstress.5x3.skin.png (stress in skin only)



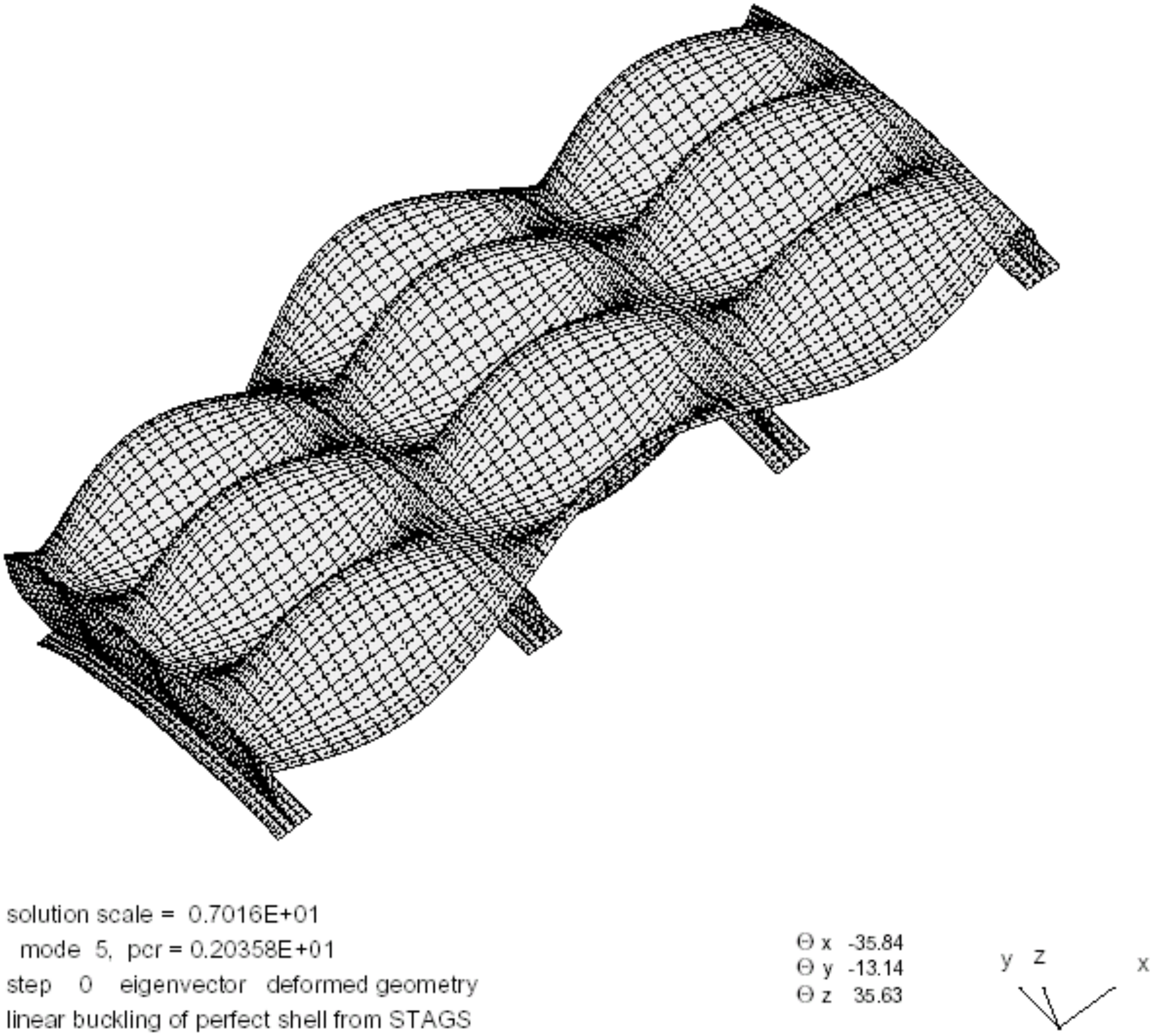
18.cylstif.stagsunit.innerfibstress.skin.zoom.png (zoomed view from previous plot)



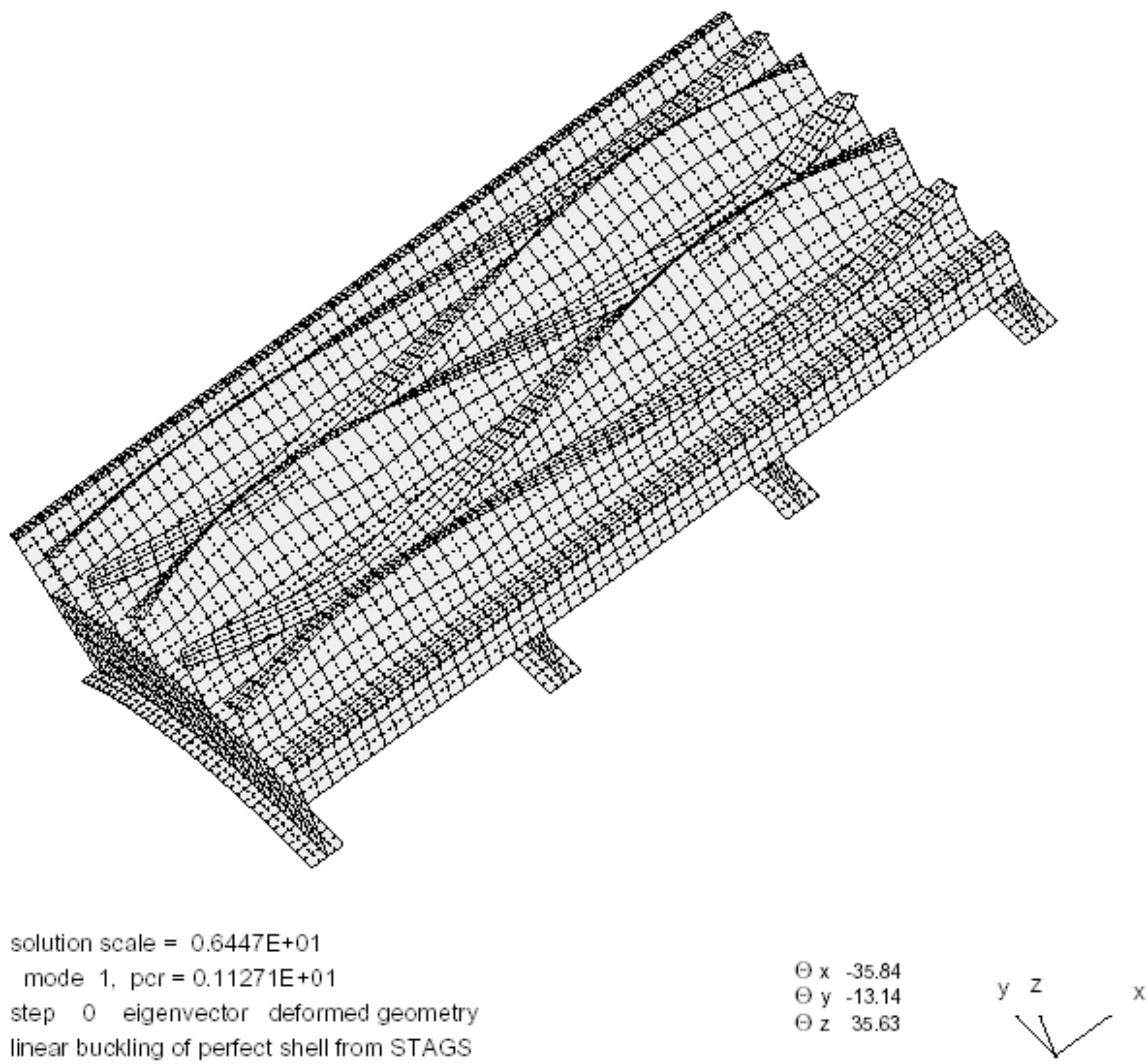
19.cylstif.stagsunit.outerfibstress.skin.zoom.png (outer fiber stress in the skin)



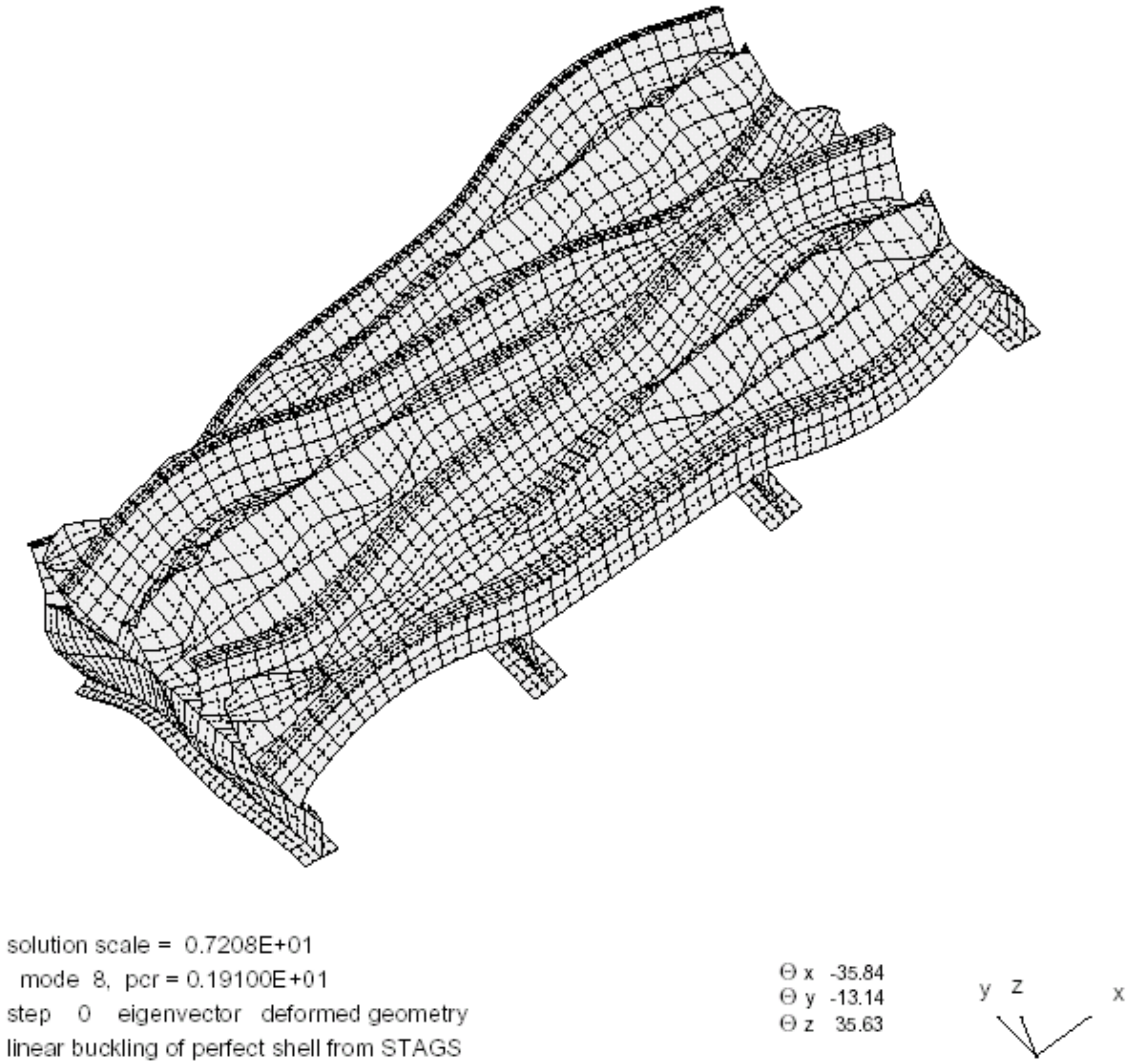
20.cylstif.stagsunit.innerfibstress.webzoom.png (local stress concentrations at the web roots. PANDA2 cannot capture this type of local concentration of stress at the edges.)



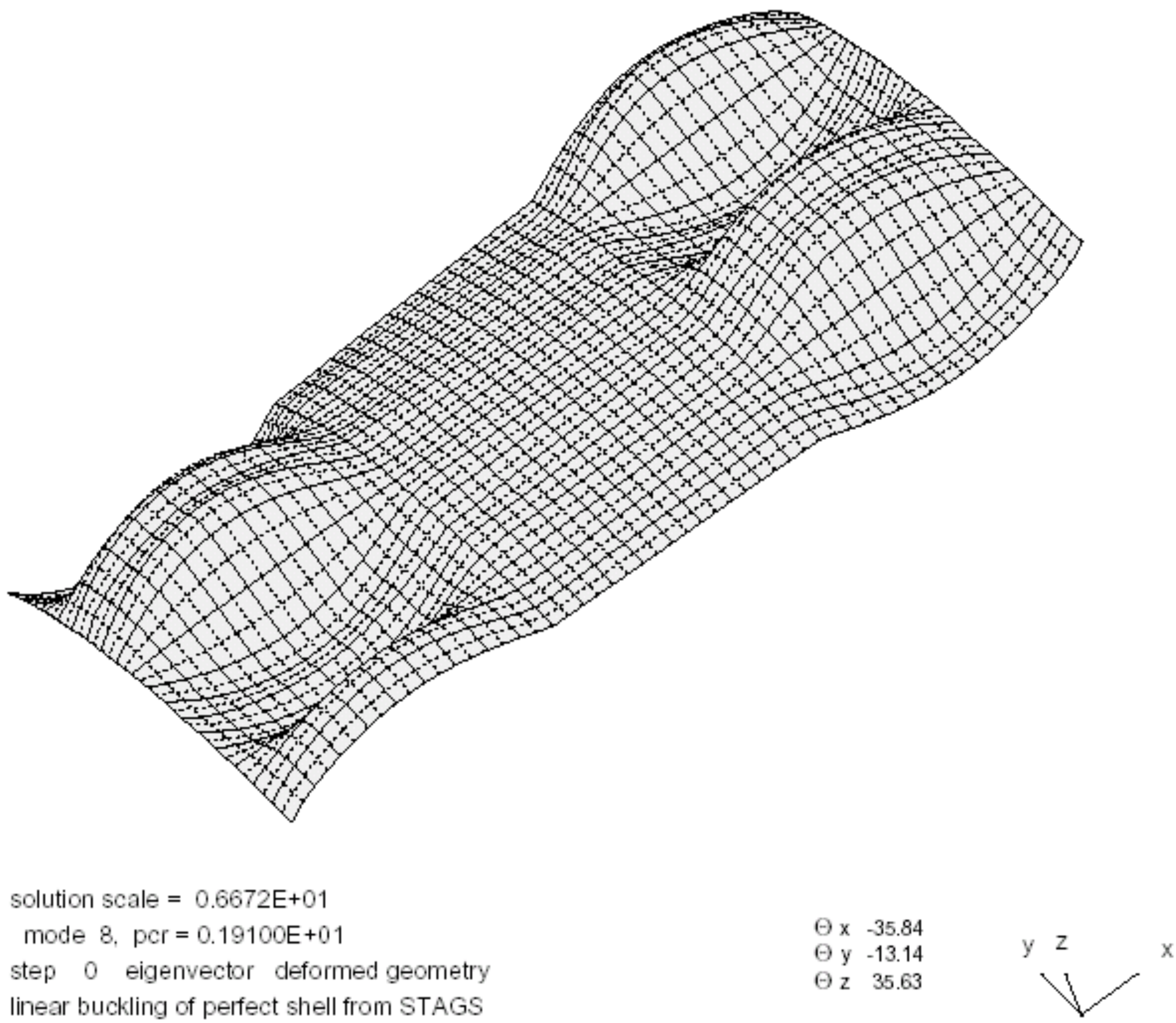
21.cylstif.stagsunit.6x3.smrstr.eig5.png (critical inter-ring buckling mode, smeared stringers. The critical inter-ring buckling mode corresponds to the 5th eigenvalue. The previous 4 eigenvalues correspond to various ring sidesway buckling modes without participation of the panel skin-with-smeared-stringers.)



22.cylstif.stagsunit.6x3.eig1.png (critical local buckling load factor from sub-domain 6 x 3 bay model in which all stiffener segments are modeled as flexible shell units.)



23.cylstif.stagsunit.6x3.eig43.png (The 43rd eigenvalue corresponds to the critical inter-ring buckling mode from a model in which all of the stiffener segments are modeled as flexible shell units)



24.cylstif.stagsunit.6x3.eig43.skin.png (same inter-ring buckling mode as shown in the previous figure; only the shell unit that represents the skin is plotted here.)