riks.axial.realstiff.chap1.opm

The numbers of the references [ ] given in the CHAPTER headings correspond to those listed at the end of 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

The overall structure of PANDA2 and its use are described in the first PANDA2 paper, Ref.[1A], cited in the April 2007 paper just identified. Ref.[1A] is the following paper:
Bushnell, D.,
"PANDA2 - Program for minimum weight design of stiffened, composite, locally buckled panels", COMPUTERS AND STRUCTURES, Vol. 25, No. 4, pp 469-605, 1987

Concepts such as "wide-column" buckling, "discretized module model", "stringer pop-off", "constitutive matrices" "reduction factor for transverse shear deformtion (t.s.d.)" "smeared stiffeners", "neutral surface", "overall and local static response to uniform pressure", "knockdown factors for anisotropy and in-plane shear loading", "crippling of stiffener parts", and "local postbuckling" are described there, with many early PANDA2 examples provided.

The string, "PANDA-type theory" often occurs. This refers to the theory presented in Ref. [1B] of the April 2007 citation listed first. Ref.[1B] contains the theory given in the paper:
Bushnell, D.,
"Theoretical basis of the PANDA computer program for preliminary design of stiffened panels under combined in-plane loads", COMPUTERS & STRUCTURES, v. 27, No. 4, pp 541-563 (1987).

The theory used for local postbuckling behavior appears in Ref. [1C] of the April 2007 paper cited first (above).
Ref. [1C] is the following paper:
Bushnell, D.,
"Optimization of composite, stiffened, imperfect panels under combined loads for service in the postbuckling regime", Computer Methods in Applied Mechanics and Engineering, Vol. 103 (1993) 43-114

The theory used for imperfection sensitivity appears in Refs. [1E] and [1D] of the first-cited paper above.
Refs. [1E] and [1D] are the following two papers:

Bushnell, D. and Bushnell, W. D.,
"Approximate method for the optimum design of ring and stringer stiffened cylindrical panels and shells with local, inter-ring, and general buckling modal imperfections" Computers and Structures, Vol. 59, No. 3, pp 489-527 (1996)

Bushnell, D.,
"Recent enhancements to PANDA2" AIAA Paper 96-1337-CP, Proc. of the AIAA 37th Structures, Structural Dynamics and Materials Conference, pp 126-182, April, 1996.

The last paper cited also describes the "global" optimizer, "SUPEROPT", implementation of Sanders shell equations into PANDA2, implementation of the Arbocz theory for imperfection sensitivity, implementation of isogrid geometry, and implementation of various truss-core geometries, with examples.

The theories used in PANDA2 for the analysis of sandwich walls are given in Ref.[1F] of the first-cited paper above.
Ref. [1K] is the following paper:
Bushnell, D.,
"Optimum design via PANDA2 of composite sandwich panels with honeycomb or foam cores", AIAA Paper 97-1142, Proc. 38th AIAA Structures, Structural Dynamics and Materials Conference, pp 2163-2202, April, 1997

The "alternate" (double-trigonometric series expansion buckling theory) and the discretized "skin"-ring module model are described in Ref. [1G] of the first-cited paper.

Table 1.33 (p. 2 of 5)

Ref. [1G] is the following paper:
Bushnell, D., Jiang, H., and Knight, N.F.,
"Additional buckling solutions in PANDA2", Proceedings of the 40th AIAA SDM Conference, AIAA Paper 99-1233, pp 302-345
April 1999

Details of the strategy used in PANDA2 for accounting for initial buckling modal imperfections are described and listed in a table in Ref. [1K]. Ref. [1K] is the following paper:
Bushnell, D. and Rankin, C.C.,
"Difficulties in optimization of imperfect stiffened cylindrical shells",
AIAA Paper 1943, 47th AIAA Structures, Structural Dynamics and Materials Meeting, Newport RI, April 2006

```
************************************************************
ENTERING SUBROUTINE STRUCT
****************     TABLE OF CONTENTS    ********************
CHAPTER 1  Compute the 6 x 6 constitutive matrices [C] for
           individual model segments and various combinations
           thereof (skin with smeared stiffener sets [1A]).
CHAPTER 2  Do PANDA-type [1B] general buckling analysis to
           get Donnell factors for later use, if appropriate.
CHAPTER 3  Do various PANDA-type [1B] general buckling
           analyses needed for later computation of effective
           length of the panel. Compute the effective length.

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
CHAPTER 4  Compute axisymmetric prebuckling "hungry-horse"
           state of the curved panel or cylindrical shell.
           (See Ref.[1E]).
CHAPTER 5  Get static response of panel to normal pressure
           [1A].
CHAPTER 6  Do PANDA-type [1B] general and inter-ring buckling
           analyses to permit later computation of
           amplification of panel bowing.
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]).
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]).
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).
CHAPTER 10 Compute knockdown factors and prebuckling bending
           associated with initial general, inter-ring, local
           buckling modal imperfections. (See Ref.[1E]).
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)
CHAPTER 10.2 Compute knockdown factor and prebuckling bending
             associated with inter-ring buckling modal
             initial imperfection.
CHAPTER 10.3 Compute knockdown factor and prebuckling bending
             associated with local buckling modal initial
             imperfection.
CHAPTER 10.4 Present a summary of imperfection sensitivity
             results. (See Section 13 and Table 9 of [1K])
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, gen-
           eral 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])

CHAPTER 12 List 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.

CHAPTER 13 List 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).

CHAPTER 14 Compute local buckling from BOSOR4-type discretized skin-stringer single module model. See Section 12.2 in [1A].

CHAPTER 15 Compute bending-torsion (low-m) buckling from BOSOR4-type discretized skin-stringer single module model. See Section 12.2 in [1A].

CHAPTER 16 Compute post-local buckling from the Koiter theory given in Ref.[1C]. (Figs. 23, 24 in [1A] and Fig. 6 in [1C]).

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 [1A].SUBROUTINE STRTHK is used.

CHAPTER 18 Present summary of state of loaded imperfect panel and give effective stiffnesses of possibly locally postbuckled skin-stringer module. These effective stiffnesses (Table 12 of Ref. [18]) are used later for overall buckling and inter-ring buckling.

CHAPTER 19 Do wide-column inter-ring buckling analysis with possibly locally postbuckled skin-stringer module model. (See Fig. 20c of [1A]).

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].

CHAPTER 20b Compute high-m buckling of single discretized skin-stringer module (same model as used in CHAPTER 14 except explored in the range of high numbers of axial halfwaves). See panda2.news Item Number 682.

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.

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]).

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).

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].

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].

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.

CHAPTER 27 Compute the objective function (e.g. WEIGHT).

CHAPTER 28 Present design, loading, and margins for the current load set and subcase. (See Table 6 in [18])

Table 1.33 (p.4 of 5)

```
*****************************************************************
 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].

*** BEGIN SUBROUTINE GETCIJ (CONSTIT. LAW: SEGS AND SMEARED ***
 See Section 8, pp 494-503 of Reference [1A]. First the 6 x 6
 integrated constitutive coefficients Cij (Eq.8.1) and thermal
 loading are found for each segment in the skin-stringer module
 then for the skin-ring module, then for the skin with smeared
 stringers only, then for the skin with smeared rings only,
 and finally for the skin with both stringers and rings smeared.


 CONSTITUTIVE MATRIX C(i,j) FOR SKIN-STRINGER MODULE                      THERMAL {NT}  ETHER»
M {ET}

 UNIQUE SKIN-STRINGER MODULE iSEGMENT NO. 1:   PANEL  SKIN                 THERMAL {NT}  ETHER»
M {ET}
  7.0553E+05  2.1166E+05  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00   0.0000E+00  0.0000»
E+00
  2.1166E+05  7.0553E+05  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00   0.0000E+00  0.0000»
E+00
  0.0000E+00  0.0000E+00  2.4694E+05  0.0000E+00  0.0000E+00  0.0000E+00   0.0000E+00  0.0000»
E+00
  0.0000E+00  0.0000E+00  0.0000E+00  2.4235E+02  7.2706E+01  0.0000E+00   0.0000E+00  0.0000»
E+00
  0.0000E+00  0.0000E+00  0.0000E+00  7.2706E+01  2.4235E+02  0.0000E+00   0.0000E+00  0.0000»
E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  8.4823E+01   0.0000E+00  0.0000»
E+00

 UNIQUE SKIN-STRINGER MODULE iSEGMENT NO. 2: STRINGER BASE                 THERMAL {NT}  ETHER»
M {ET}
  7.0553E+05  2.1166E+05  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00   0.0000E+00  0.0000»
E+00
  2.1166E+05  7.0553E+05  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00   0.0000E+00  0.0000»
E+00
  0.0000E+00  0.0000E+00  2.4694E+05  0.0000E+00  0.0000E+00  0.0000E+00   0.0000E+00  0.0000»
E+00
  0.0000E+00  0.0000E+00  0.0000E+00  2.4235E+02  7.2706E+01  0.0000E+00   0.0000E+00  0.0000»
E+00
  0.0000E+00  0.0000E+00  0.0000E+00  7.2706E+01  2.4235E+02  0.0000E+00   0.0000E+00  0.0000»
E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  8.4823E+01   0.0000E+00  0.0000»
E+00

 UNIQUE SKIN-STRINGER MODULE iSEGMENT NO. 3: STRINGER WEB                  THERMAL {NT}  ETHER»
M {ET}
  1.9942E+06  5.9827E+05  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00   0.0000E+00  0.0000»
E+00
  5.9827E+05  1.9942E+06  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00   0.0000E+00  0.0000»
E+00
  0.0000E+00  0.0000E+00  6.9798E+05  0.0000E+00  0.0000E+00  0.0000E+00   0.0000E+00  0.0000»
E+00
  0.0000E+00  0.0000E+00  0.0000E+00  5.4729E+03  1.6419E+03  0.0000E+00   0.0000E+00  0.0000»
E+00
  0.0000E+00  0.0000E+00  0.0000E+00  1.6419E+03  5.4729E+03  0.0000E+00   0.0000E+00  0.0000»
E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  1.9155E+03   0.0000E+00  0.0000»
E+00

 Location of skin-stringer module centroid, ECCN=  4.0732E-01
 Effective skin-stringer module EI per length
 of circumferential arc of the panel, EIEFF=  4.9955E+05
 Inter-ring skin-stringer single module treated as an Euler
 column: buckling load/circ.arclength, FNCRIT=  1.9721E+03
 Compare FNCRIT to the wide-column buckling load. That gives
 you an idea what the combined knockdown factor should
 be for (1) smearing the stringers, + (2) the effect of t.s.d.
 The effective length of the Euler column is B(2)=  5.0000E+01


C(i,j) with smeared stringers only...                                    THERMAL {NT}  ETHERM»
{ET}
Reference surface is at the refer. surface of the skin midway between the stringers.newsITEM 27»
```

Table 1.33 (p. 5 of 5)

4

```
  1.0891E+06  2.1166E+05  0.0000E+00  4.1776E+05  0.0000E+00  0.0000E+00      0.0000E+00  0.0000»
E+00
  2.1166E+05  7.0553E+05  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00      0.0000E+00  0.0000»
E+00
  0.0000E+00  0.0000E+00  2.4694E+05  0.0000E+00  0.0000E+00  0.0000E+00      0.0000E+00  0.0000»
E+00
  4.1776E+05  0.0000E+00  0.0000E+00  5.9804E+05  7.2706E+01  0.0000E+00      0.0000E+00  0.0000»
E+00
  0.0000E+00  0.0000E+00  0.0000E+00  7.2706E+01  2.4235E+02  0.0000E+00      0.0000E+00  0.0000»
E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  4.8974E+02      0.0000E+00  0.0000»
E+00


 C(i,j) with smeared stringers and reduced stiffness
 for Segment 1 of the panel skin.


 If FSLOC.LT.0.95 (post-local-buckling allowed) the following
 C(i,j) are used for the prediction of preliminary general
 instability, the purpose of which is to establish, for flat
 panels, how much any axial bowing amplitude grows under the
 applied axial load.
  1.0891E+06  2.1166E+05  0.0000E+00  4.1776E+05  0.0000E+00  0.0000E+00
  2.1166E+05  7.0553E+05  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  2.4694E+05  0.0000E+00  0.0000E+00  0.0000E+00
  4.1776E+05  0.0000E+00  0.0000E+00  5.9804E+05  7.2706E+01  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  7.2706E+01  2.4235E+02  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  4.8974E+02


 LOCATION OF THE NEUTRAL PLANE FOR AXIAL LOADING
 AND C(i,j) WITH SMEARED STIFFENERS. Reference surface for the
 following C(i,j) is the neutral plane for axial loading.
 Negative d corresponds to a neutral plane that lies above
 the plane of the reference surf. of the lowest panel skin.
 See Fig. 15a on page 502 of Reference [1].
 d =  -4.0732E-01

  1.0891E+06  2.1166E+05  0.0000E+00 -2.5864E+04 -8.6213E+04  0.0000E+00
  2.1166E+05  7.0553E+05  0.0000E+00 -8.6213E+04 -2.8738E+05  0.0000E+00
  0.0000E+00  0.0000E+00  2.4694E+05  0.0000E+00  0.0000E+00 -1.0058E+05
 -2.5864E+04 -8.6213E+04  0.0000E+00  4.3842E+05  3.5189E+04  0.0000E+00
 -8.6213E+04 -2.8738E+05  0.0000E+00  3.5189E+04  1.1730E+05  0.0000E+00
  0.0000E+00  0.0000E+00 -1.0058E+05  0.0000E+00  0.0000E+00  4.1459E+04
 **** END   SUBROUTINE GETCIJ (CONSTIT. LAW: SEGS AND SMEARED ***
```

Table 1.34

riks.axial.realstiff.chap13.opm

```
 ***********************************************************
 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.).

 Effective circumferential radius of curvature, RADNEW=  7.0711E+07
       External Stringer

      MODULE WITH RECTANGULAR STIFFENER...

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

   EXPLODED VIEW, SHOWING LAYERS and (SEGMENT, NODE) NUMBERS

                                  (3,11)
                                    !
          Layer No. 1 -----> ! <---------- Layer No. k
                                    !
       Layer No. 1-.                !
                        .           !
  Layer No. 1-.          .          !               .-Layer No. 1
              .            .        !               .
             .              .   (3,1)                .
   --------------    =====================    ---------------
 (1,1)    .    (1,11)(2,1)    . (2,6)    (2,11)(4,1)    .    (4,11)
         .                   .                           .
        .                   .                             .
           Layer No. m       Layer No. n     Layer No. m

 ============================================
 BEGIN: PREBUCKLING STRESS RESULTANTS USED IN THE
 DISCRETIZED SINGLE MODULE MODEL WITH IQUICK = 0...
 -- -----------------------------------------------------
 PREBUCKLING STRESS RESULTANTS AT THE FIRST NODE
 IN THE DISCRETIZED SINGLE MODULE SEGMENT NO. 1 .....
  "Total." loads, Nx(var),Ny(var),Nxy(var)= -6.2598E+02  2.1273E-05  5.0000E+00
  "Fixed " loads, Nx(fix),Ny(fix),Nxy(fix)=  0.0000E+00  0.0000E+00  0.0000E+00
 PREBUCKLING STRESS RESULTANTS AT THE FIRST NODE
 IN THE DISCRETIZED SINGLE MODULE SEGMENT NO. 2 .....
  "Total." loads, Nx(var),Ny(var),Nxy(var)= -6.2598E+02  2.1273E-05  5.0000E+00
  "Fixed " loads, Nx(fix),Ny(fix),Nxy(fix)=  0.0000E+00  0.0000E+00  0.0000E+00
 PREBUCKLING STRESS RESULTANTS AT THE FIRST NODE
 IN THE DISCRETIZED SINGLE MODULE SEGMENT NO. 3 .....
  "Total." loads, Nx(var),Ny(var),Nxy(var)= -1.7694E+03  0.0000E+00  4.5355E-06
  "Fixed " loads, Nx(fix),Ny(fix),Nxy(fix)=  0.0000E+00  0.0000E+00  0.0000E+00

 AXIAL CURVATURE CHANGES FROM SOURCES OTHER THAN
 INITIAL IMPERFECTIONS (FROM EPSLOD(4) AND ETHERM(4))...
  "Eigenvalue" axial curvature change
       CURVAR = EPSLOD(4) - FFIABT*ETHERM(4) =  4.4996E-11
  "Fixed" axial curvature change
       CURFIX = EPSLDF(4)                    =  0.0000E+00

 PREBUCKLING AXIAL RESULTANTS IN STRINGER WEB: SEGMENT NO.  3
  "Eigenvalue" axial resultant, Nx(var)=
 -1.7694E+03 -1.7694E+03 -1.7694E+03 -1.7694E+03 -1.7694E+03 -1.7694E+03
 -1.7694E+03 -1.7694E+03 -1.7694E+03 -1.7694E+03 -1.7694E+03
  "  fixed    " axial resultant, Nx(fix)=
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 PREBUCKLING STRESS RESULTANTS AT THE FIRST NODE
 IN THE DISCRETIZED SINGLE MODULE SEGMENT NO. 4 .....
```

Single panel module

Table 1.34 (end)

```
 "Total." loads, Nx(var),Ny(var),Nxy(var)= -6.2598E+02  2.1273E-05  5.0000E+00
 "Fixed " loads, Nx(fix),Ny(fix),Nxy(fix)=  0.0000E+00  0.0000E+00  0.0000E+00
-----------------------------------------------------
END:  PREBUCKLING STRESS RESULTANTS USED IN THE
DISCRETIZED SINGLE MODULE MODEL WITH IQUICK = 0...
==========================================================
```

Table 1.35

riks.axial.realstiff.chap14.opm

```
 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.

 EXPLANATION OF FOLLOWING CALCULATIONS (LOAD SET NO. 1):
     Eigenvalues corresponding to local buckling of the skin
     obtained from the BOSOR4-discretized panel module model
     are calculated for a range of axial wavenumbers. All four
     edges of the panel are assumed to be simply supported,
     even if you indicated "clamped" in your input, and the in-
     plane loading is assumed to be uniform (N1, N2, N12), even
     if you provided for axial load Nx varying in the L2 (cir-
     cumferential) direction.

**** BEGIN SUBROUTINE LOCAL (INITIAL LOCAL BUCKLING SEARCH) ****
 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
    7     2.62633E-01        1.00000E+00      1.00000E+00       2.62633E-01
    8     2.66073E-01        1.00000E+00      1.00000E+00       2.66073E-01
    6     2.70452E-01        1.00000E+00      1.00000E+00       2.70452E-01
    7     2.62633E-01        1.00000E+00      1.00000E+00       2.62633E-01

 ****  END  SUBROUTINE LOCAL (INITIAL LOCAL BUCKLING SEARCH) ****
  **** END OF LOCAL BUCKLING EIGENVALUE CALC.****
```

critical number of axial halfwaves

Compare with STAGS prediction (0.25038) of linear buckling given in Figs. 1.43 & 1.44.

Compare with BIGBOSOR4 prediction in Fig. 1.50 (0.26503)

Search over M for the minimum eigenvalue

Table 1.36

riks.axial.realstiff.chap15.opm

```
 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.

**** BEGIN SUBROUTINE LOCAL (LOW-M LOCAL BUCKLING SEARCH) ****
 BUCKLING LOAD FACTORS FROM BOSOR4-TYPE DISCRETIZED MODEL...
          (skin-stringer discretized module of local buckling)
  AXIAL     BUCKLING       KNOCKDOWN FOR    KNOCKDOWN FOR
  HALF-    LOAD FACTOR    TRANSVERSE SHEAR  IN-PLANE SHEAR     BUCKLING
  WAVES  BEFORE KNOCKDOWN   DEFORMATION     LOADING AND/OR   LOAD FACTOR
                                              ANISOTROPY    AFTER KNOCKDOWN
    M        EIGOLD            KSTAR            KNOCK     EIGOLD*KSTAR*KNOCK
    1      1.28972E+00      1.00000E+00      1.00000E+00     1.28972E+00
    2      6.18522E-01      1.00000E+00      1.00000E+00     6.18522E-01
    3      4.35163E-01      1.00000E+00      1.00000E+00     4.35163E-01
    4      3.43649E-01      1.00000E+00      1.00000E+00     3.43649E-01
    5      2.94503E-01      1.00000E+00      1.00000E+00     2.94503E-01
    6      2.70450E-01      1.00000E+00      1.00000E+00     2.70450E-01
    7      2.62632E-01      1.00000E+00      1.00000E+00     2.62632E-01
    7      2.62632E-01      1.00000E+00      1.00000E+00     2.62632E-01
Buckling load factor from SUB. LOCAL, EIGITR(4)=  2.6263E-01
Number of axial halfwaves between rings, NLOW=     7
**** END SUBROUTINE LOCAL (LOW-M LOCAL BUCKLING SEARCH) ******
 **** END OF LOW-AXIAL-WAVENUMBER CHECK FOR ****
 ***************   LOCAL BUCKLING   **************
```

Searching for a different minimum eigenvalue vs M than that found in the previous table. In this case a "low-m" minimum different from that already found at M=7 was not discovered, but often there is a low-m minimum in other cases. PANDA2 always checks if IQUICK=0.

Table 1.37 (1 of 6)

riks.axial.realstiff.chap16.opm

```
 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

*** BEGIN CALCULATIONS RELATING TO THE KOITER THEORY ***
*** See Ref.[3]: Bushnell, D., "Optimization of composite,
*** stiffened, imperfect panels under combined loads for
*** service in the posbuckling regime", CMAME, vol.103,
*** pp 43-114 (1993)
** BEGIN SUBROUTINE INTMOD (INTEGRALS OF PRODUCTS OF MODES) **
 SUB.INTMOD computes the quantities given on pp 58 and 59 of
 the paper just cited.
 **** END SUBROUTINE INTMOD (INTEGRALS OF PRODUCTS OF MODES) ****

 EXPLANATION OF FOLLOWING CALCULATIONS (LOAD SET NO. 1):
  Corresponding to M=  7 waves from the local buckling
  analysis above, the distributions of Nx, Ny, and Nxy
  in the locally imperfect and additionally deformed panel are
  next calculated.  The maximum stress components in the
  deformed skin as well as in the stiffener segments are also
  computed. In addition, the tangent membrane stiffness CTAN
  in the locally deformed skin is calculated.  CTAN is needed
  for subsequent calculation of the load factor corres-
  ponding to wide column panel buckling (buckling between
  rings) and general instability.

  BEFORE POSSIBLE CHANGE: INITIAL LOCAL IMPERFECTION W0=  0.0064203213
  AFTER POSSIBLE CHANGE: INITIAL LOCAL IMPERFECTION W0=  0.0064203213
  IF W0 WAS CHANGED, SEE PANDA2.NEWS ITEM 141 FOR WHY IT WAS

***** BEGIN SUBROUTINE KOIT2 (KOITER THEORY POSTBUCKLING) ****

 ******** ENTERING KOITER BRANCH, SUBROUTINE KOIT2 *********
 This subroutine is an implementation of the theory described
 in the PANDA2 paper by David Bushnell:
     "Optimization of composite, stiffened, imperfect panels
      under combined loads for service in the postbuckling
      regime", Computer Methods in Applied Mechanics and
      Engineering, Vol. 103 (1993) 43-114 (volume in honor of
      Besselings 65th birthday).

 NOTE: Computations herein do not include the effect of
       "hungry-horse" adjustments to the hoop resultant in the
       panel skin: FNYADJ=  0.0000E+00 for Load Set A and
                   FNYAD0=  0.0000E+00 for Load Set B.
       unless a negative eigenvalue is computed in SUBROUTINE
       EIGKOI.

 BIFURCATION BUCKLING EIGENVALUE FROM KOITER-TYPE THEORY
  AXIAL    ITER.    SLOPE       DSLOPE       EIGKOI
  WAVES     NO.       m           dm
    7         1  4.9279E-03  3.9279E-03  2.5842E-01
    7         2  4.9278E-03 -1.6139E-07  2.5843E-01
    7         3  4.9278E-03  4.2720E-10  2.5843E-01

 LOCAL BIFURCATION BUCKLING LOAD FACTOR ESTIMATES
 AND AMPLITUDE Wo OF LOCAL IMPERFECTION, Wo*(buckling mode)
 Critical number of axial half-waves                 =  7
 Slope of buckling nodal lines from Koiter Theory, m=  4.93E-03
 Knockdown factor for C44, C45, C55 for transv.shear=  1.00E+00
 Local buckling load Factor from Koiter-type Theory =  2.58E-01
 Load Factor from BOSOR4-type panel module model    =  2.63E-01
 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 =  2.63E-01
 Amplitude Wo of local imperfection                  =  6.4203E-03

 ENTERING "NEWTON", LABEL=8002; IMOD= 0

 NONLINEAR POST-LOCAL BUCKLING BEHAVIOR WITH
 INITIAL LOCAL IMPERFECTION IGNORED  (Wo = 0):
```

Table 1.37 (2 of 6)

```
SUBROUTINE NEWTON CALLED FROM KOIT2 AT LABEL= 8002
NEWTON ITERATIONS BEGIN; SLOPE=  4.9278E-03; a=  0.0000E+00; f=  0.0000E+00
Imperfection, Wo=  0.0000E+00; Load Perturbation=  0.0000E+00
 ITER   SLOPE        DSLOPE          a            da           f            df
   1  1.9068E-02  1.4140E-02  0.0000E+00  0.0000E+00  1.7754E-01  1.9957E-05
   2  1.9066E-02 -2.0675E-06  0.0000E+00  0.0000E+00  1.7753E-01  4.2679E-13
   3  1.9066E-02  1.2917E-09  0.0000E+00  0.0000E+00  1.7753E-01  1.6658E-19
LEAVING "NEWTON", LABEL=8002; IMOD,NOCONV= 0 0
SOLN FROM "NEWTON": F,AL,M;  N=  1.7753E-01  0.0000E+00  1.9066E-02  4.8361E-02
ENTERING "NEWTON", LABEL=8004; IMOD= 0

NONLINEAR POST-LOCAL BUCKLING BEHAVIOR WITH
INITIAL LOCAL IMPERFECTION INCLUDED (Wo =  6.4203E-03):

SUBROUTINE NEWTON CALLED FROM KOIT2 AT LABEL= 8004
NEWTON ITERATIONS BEGIN; SLOPE=  1.9066E-02; a=  0.0000E+00; f=  1.7753E-01
Imperfection, Wo=  6.4203E-03; Load Perturbation=  0.0000E+00
 ITER   SLOPE        DSLOPE          a            da           f            df
   1  2.0445E-02  1.3787E-03  0.0000E+00  0.0000E+00  1.7254E-01 -4.9858E-03
   2  2.0486E-02  4.1479E-05  0.0000E+00  0.0000E+00  1.7233E-01 -2.1076E-04
   3  2.0486E-02  5.2972E-08  0.0000E+00  0.0000E+00  1.7233E-01 -3.6972E-07
LABEL= 8004 CONVERGENCE OF LOCAL STATE SUCCESSFUL! IMOD= 0
SOLUTION FROM "NEWTON", F,AL,M=  1.7233E-01  0.0000E+00  2.0486E-02
LEAVING "NEWTON", LABEL=8004; IMOD,NOCONV= 0 0
SOLN FROM "NEWTON": F,AL,M;  N=  1.7233E-01  0.0000E+00  2.0486E-02  4.8361E-02
ENTERING "NEWTON", LABEL=8004; IMOD= 0

NONLINEAR POST-LOCAL BUCKLING BEHAVIOR WITH
INITIAL LOCAL IMPERFECTION INCLUDED (Wo =  6.4203E-03):

SUBROUTINE NEWTON CALLED FROM KOIT2 AT LABEL= 8004
NEWTON ITERATIONS BEGIN; SLOPE=  2.0486E-02; a=  0.0000E+00; f=  1.7233E-01
Imperfection, Wo=  6.4203E-03; Load Perturbation=  0.0000E+00
 ITER   SLOPE        DSLOPE          a            da           f            df
   1  2.0486E-02  1.8494E-09  0.0000E+00  0.0000E+00  1.7233E-01  8.1784E-09
   2  2.0486E-02  4.3593E-10  0.0000E+00  0.0000E+00  1.7233E-01 -7.3751E-09
   3  2.0486E-02  4.3593E-10  0.0000E+00  0.0000E+00  1.7233E-01 -7.3751E-09
LABEL= 8004 CONVERGENCE OF LOCAL STATE SUCCESSFUL! IMOD= 0
SOLUTION FROM "NEWTON", F,AL,M=  1.7233E-01  0.0000E+00  2.0486E-02
LEAVING "NEWTON", LABEL=8004; IMOD,NOCONV= 0 0
SOLN FROM "NEWTON": F,AL,M;  N=  1.7233E-01  0.0000E+00  2.0486E-02  4.8361E-02

NEWTON ITERATIONS BEGIN IN SUBROUTINE ENERGY
CALLED FROM SUBROUTINE KOIT2 AT LABEL = 8010.
PURPOSE IS TO OBTAIN NEW SOLUTION ALLOWING THE AXIAL
HALFWAVELENGTH OF THE LOCAL POSTBUCKLED PATTERN TO CHANGE.

ITER.        UNKNOWNS IN THE LOCAL POSTBUCKLING PROBLEM
 NO.    AMPLITUDE    FLATTENING    NODAL LINE  PI**2*n**2/4L**2   AXIAL HALFWAVELENGTH
            f              a         SLOPE,  m          N          OF BUCKLES,(L/n)
 0     1.72333E-01  -1.00000E-04   2.04861E-02   4.83611E-02   7.14285E+00
 1     1.64532E-01  -1.00000E-04   1.99007E-02   5.26533E-02   6.84552E+00
 2     1.63890E-01  -1.00000E-04   1.98338E-02   5.33099E-02   6.80324E+00
 3     1.63839E-01  -1.00000E-04   1.98298E-02   5.33428E-02   6.80114E+00
 CONVERGENCE SUCCESSFUL!
YES CONVERGENCE IN "ENERGY", LABEL=8010: IMOD,F,AL,M,N= 0
 1.6384E-01 -1.0000E-04  1.9830E-02  5.3343E-02
VALUES FOR UNPERTURBED DESIGN: F,A,M,N=   1.64E-01  -1.00E-04   1.98E-02   5.33E-02
ENTERING "NEWTON", LABEL=8240; IMOD= 0

NONLINEAR POST-LOCAL BUCKLING BEHAVIOR WITH
INITIAL LOCAL IMPERFECTION INCLUDED (Wo =  6.4203E-03):

SUBROUTINE NEWTON CALLED FROM KOIT2 AT LABEL= 8240
NEWTON ITERATIONS BEGIN; SLOPE=  1.9830E-02; a= -1.0000E-04; f=  1.6384E-01
Imperfection, Wo=  6.4203E-03; Load Perturbation=  0.0000E+00
 ITER   SLOPE        DSLOPE          a            da           f            df
   1  1.9830E-02  2.9702E-07 -1.0000E-04  0.0000E+00  1.6381E-01 -3.3447E-05
   2  1.9830E-02  5.9995E-10 -1.0000E-04  0.0000E+00  1.6381E-01 -3.6227E-09
   3  1.9830E-02  5.9995E-10 -1.0000E-04  0.0000E+00  1.6381E-01 -3.6227E-09
LABEL= 8240 CONVERGENCE OF LOCAL STATE SUCCESSFUL! IMOD= 0
SOLUTION FROM "NEWTON", F,AL,M=  1.6381E-01 -1.0000E-04  1.9830E-02
LEAVING "NEWTON", LABEL=8240; IMOD,NOCONV= 0 0
SOLN FROM "NEWTON": F,AL,M;  N=  1.6381E-01 -1.0000E-04  1.9830E-02  5.3343E-02
 AMPLITUDES: F00, F =  0.163838819  0.163805366
VALUES FOR UNPERTURBED DESIGN: F,A,M,N=   1.64E-01  -1.00E-04   1.98E-02   5.33E-02
```

```
LOCAL DEFORMATION CHARACTERISTICS:
Average axial strain(not including thermal),EXAVE = -1.3767E-03
Initial local imperfection amplitude,            Wo=  6.4203E-03
Slope of local buckling nodal lines in skin     M =  1.9830E-02
Parameter "a" in the expression f*(phi +a*phi**3) = -1.0000E-04
Amplitude  f  in the expression f*(phi +a*phi**3) =  1.6381E-01
Normal displacement amplitude between stringers W =  1.6379E-01
Number of axial halfwaves at local bifurcation    =     7
Number of axial halfwaves in postbuckled regime   =  7.3517E+00
Convergence characteristic,               NOCONV  =  0


RESULTS FOR  7.3517E+00 AXIAL WAVES...
LOCAL DEFORMATION PARAMETERS:
   SLOPE, a, f         =  1.9830E-02 -1.0000E-04  1.6381E-01
APPLIED STRESS RESULTANTS (Load set A):
   Nx, Ny, Nxy         = -1.0000E+03  0.0000E+00  5.0000E+00
APPLIED STRESS RESULTANTS (Load set B):
  Nxo, Nyo, Nxyo       =  0.0000E+00  0.0000E+00  0.0000E+00
STRAIN AND STRESS FROM APPLIED LOADS:
AVERAGE STRAIN COMPONENTS:
  EPS1, EPS2, EPS12    = -1.3767E-03 -1.2405E-04  4.5582E-05
AVERAGE RESULTANTS IN SKIN:
N1SKIN,N2SKIN,N12SKIN= -4.7188E+02 -4.6931E-06  5.0000E+00
NOTE: N1SKIN includes average of Nx in skin and stringer base.

 -------------------------------------------
 PERTURB THE APPLIED AXIAL LOAD, Nx...
ENTERING "NEWTON", LABEL=8250; IMOD= 0

SUBROUTINE NEWTON CALLED FROM KOIT2 AT LABEL= 8250
NEWTON ITERATIONS BEGIN; SLOPE=  1.9830E-02; a= -1.0000E-04; f=  1.6381E-01
Imperfection, Wo=  6.4203E-03; Load Perturbation=  2.0000E+01
 ITER   SLOPE        DSLOPE          a            da           f           df
   1  1.9810E-02 -2.0051E-05 -1.0000E-04  0.0000E+00  1.6608E-01  2.2791E-03
   2  1.9811E-02  6.5840E-07 -1.0000E-04  0.0000E+00  1.6604E-01 -4.4482E-05
   3  1.9811E-02 -1.3789E-09 -1.0000E-04  0.0000E+00  1.6604E-01 -2.2989E-08
LABEL= 8250 CONVERGENCE OF LOCAL STATE SUCCESSFUL! IMOD= 0
SOLUTION FROM "NEWTON", F,AL,M=  1.6604E-01 -1.0000E-04  1.9811E-02
LEAVING "NEWTON", LABEL=8250; IMOD,NOCONV= 0 0
SOLN FROM "NEWTON": F,AL,M;  N=  1.6604E-01 -1.0000E-04  1.9811E-02  5.3343E-02
 -------------------------------------------
 PERTURB THE APPLIED HOOP LOAD, Ny...
ENTERING "NEWTON", LABEL=8260; IMOD= 0

SUBROUTINE NEWTON CALLED FROM KOIT2 AT LABEL= 8260
NEWTON ITERATIONS BEGIN; SLOPE=  1.9830E-02; a= -1.0000E-04; f=  1.6381E-01
Imperfection, Wo=  6.4203E-03; Load Perturbation=  1.2956E+01
 ITER   SLOPE        DSLOPE          a            da           f           df
   1  2.0899E-02  1.0689E-03 -1.0000E-04  0.0000E+00  1.6533E-01  1.5243E-03
   2  2.0889E-02 -9.7240E-06 -1.0000E-04  0.0000E+00  1.6531E-01 -2.0100E-05
   3  2.0889E-02 -2.5115E-09 -1.0000E-04  0.0000E+00  1.6531E-01  3.7026E-09
LABEL= 8260 CONVERGENCE OF LOCAL STATE SUCCESSFUL! IMOD= 0
SOLUTION FROM "NEWTON", F,AL,M=  1.6531E-01 -1.0000E-04  2.0889E-02
LEAVING "NEWTON", LABEL=8260; IMOD,NOCONV= 0 0
SOLN FROM "NEWTON": F,AL,M;  N=  1.6531E-01 -1.0000E-04  2.0889E-02  5.3343E-02
 -------------------------------------------
 PERTURB THE APPLIED IN-PLANE SHEAR LOAD, Nxy...
ENTERING "NEWTON", LABEL=8270; IMOD= 0

SUBROUTINE NEWTON CALLED FROM KOIT2 AT LABEL= 8270
NEWTON ITERATIONS BEGIN; SLOPE=  1.9830E-02; a= -1.0000E-04; f=  1.6381E-01
Imperfection, Wo=  6.4203E-03; Load Perturbation=  4.5346E+00
 ITER   SLOPE        DSLOPE          a            da           f           df
   1  3.7815E-02  1.7984E-02 -1.0000E-04  0.0000E+00  1.6387E-01  6.0118E-05
   2  3.7799E-02 -1.5854E-05 -1.0000E-04  0.0000E+00  1.6385E-01 -1.5150E-05
   3  3.7799E-02 -1.1534E-09 -1.0000E-04  0.0000E+00  1.6385E-01  7.0969E-09
LABEL= 8270 CONVERGENCE OF LOCAL STATE SUCCESSFUL! IMOD= 0
SOLUTION FROM "NEWTON", F,AL,M=  1.6385E-01 -1.0000E-04  3.7799E-02
LEAVING "NEWTON", LABEL=8270; IMOD,NOCONV= 0 0
SOLN FROM "NEWTON": F,AL,M;  N=  1.6385E-01 -1.0000E-04  3.7799E-02  5.3343E-02
 -------------------------------------------

 3X3 MATRICES FOR STRAIN AND FORCE CHANGE...
     EMAT, THE STRAIN-CHANGE MATRIX          NMAT, THE FORCE-CHANGE MATRIX
      d(EPS1)     d(EPS2)    d(EPS12)      d(N1skin)   d(N2skin)   d(N12skn)
dNx -3.013E-05 -5.173E-06  6.450E-07     -8.442E+00  7.931E-06 -4.768E-07
dNy -3.351E-06 -2.693E-05  1.828E-06      1.285E+00 -1.296E+01 -4.768E-07
```

```
dNxy -2.126E-07 -8.822E-07  4.134E-05    8.148E-02 -4.109E-06  4.535E+00

TANGENT STIFFNESS BEFORE SYMMETRIZATION
AVERAGE SKIN TANGENT STIFFNESS MATRIX
(Segments 1 and 2 averaged),    CTAN...
 2.9468E+05 -8.4278E+04  1.6876E+03
-8.4293E+04  4.9222E+05  1.0069E+04
 1.0951E+03  7.3171E+03  1.0984E+05

TANGENT STIFFNESS AFTER SYMMETRIZATION
AVERAGE SKIN TANGENT STIFFNESS MATRIX
(Segments 1 and 2 averaged),    CTAN...
 2.9468E+05 -8.4285E+04  1.3913E+03
-8.4285E+04  4.9222E+05  8.6930E+03
 1.3913E+03  8.6930E+03  1.0984E+05

(APPLIED LOAD)/(BUCKLING LOAD)=  3.8695E+00

NORMALIZED AVERAGE SKIN TANGENT STIFFNESS MATRIX
(CTAN(i,i)/CX(i,i,1), i=1,2,3) =   4.1766E-01  6.9765E-01  4.4481E-01
TANGENT POISSON RATIO
CTAN(1,2)/CTAN(1,1) =  -2.8603E-01
NORMALIZED AVERAGE (N1skin,N12skn) COUPLING
CTAN(1,3)/CX(1,1,1) =    1.9721E-03
NORMALIZED AVERAGE (N2skin,N12skn) COUPLING
CTAN(2,3)/CX(2,2,1) =    1.2321E-02

 Average tangent stiffnesses of the panel skin
have been calculated by integration of the local tangent
stiffnesses, C11TAN, C12TAN, C22TAN, and C33TAN with
Simpsons rule integration:
Average axial tangent stiffness,         CTAN(1,1) =  3.3991E+05
Average (1,2) tangent stiffness,         CTAN(1,2) =  8.2013E+03
Average hoop  tangent stiffness,         CTAN(2,2) =  4.9154E+05
Average shear tangent stiffness,         CTAN(3,3) =  1.0968E+05
These tangent stiffness components affect wide column,
general instability, and panel instability load factors.

     External Stringer

    MODULE WITH RECTANGULAR STIFFENER...

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


  EXPLODED VIEW, SHOWING LAYERS and (SEGMENT, NODE) NUMBERS

                          (3,11)
                             !
         Layer No. 1 -----> ! <----------- Layer No. k
                             !
      Layer No. 1-.          !
                     .       !
 Layer No. 1-.      .        !              .-Layer No. 1
             .         .     !               .
            .           .  (3,1)              .
 --------------   =====================   --------------
(1,1)   .   (1,11)(2,1)   . (2,6)    (2,11)(4,1)   .    (4,11)
        .                .                           .
         .                .                           .
     Layer No. m      Layer No. n    Layer No. m


        LOCALLY DEFORMED STATE IN THE PANEL MODULE SHOWN ABOVE
                PANEL MODULE HAS 4 SEGMENTS
Nodal Disp.      Membrane Strains                Resultants
Point  W       Ex         Ey         Exy        Nx         Ny         Nxy       C11TAN      C12TAN   »
C22TAN     C33TAN
```

Table 1.37 (5 of 6)

Locally Deformed State for Segment Number 1

1	1.64E-01	1.67E-04	-5.00E-05	2.02E-05	1.07E+02	2.13E-05	5.00E+00	7.06E+04	0.00E+00	4»	.92E+05	1.10E+05
2	1.62E-01	1.38E-04	-4.13E-05	2.02E-05	8.84E+01	2.13E-05	5.00E+00	7.06E+04	0.00E+00	4»	.92E+05	1.10E+05
3	1.58E-01	5.37E-05	-1.61E-05	2.02E-05	3.45E+01	2.13E-05	5.00E+00	7.06E+04	0.00E+00	4»	.92E+05	1.10E+05
4	1.50E-01	-7.86E-05	2.36E-05	2.02E-05	-5.04E+01	2.13E-05	5.00E+00	7.06E+04	0.00E+00	4»	.92E+05	1.10E+05
5	1.40E-01	-2.48E-04	7.44E-05	2.02E-05	-1.59E+02	2.13E-05	5.00E+00	7.06E+04	0.00E+00	4»	.92E+05	1.10E+05
6	1.28E-01	-4.41E-04	1.32E-04	2.02E-05	-2.83E+02	2.13E-05	5.00E+00	1.47E+05	0.00E+00	4»	.92E+05	1.10E+05
7	1.13E-01	-6.43E-04	1.93E-04	2.02E-05	-4.13E+02	2.13E-05	5.00E+00	2.48E+05	0.00E+00	4»	.92E+05	1.10E+05
8	9.68E-02	-8.37E-04	2.51E-04	2.02E-05	-5.37E+02	2.13E-05	5.00E+00	3.46E+05	0.00E+00	4»	.92E+05	1.10E+05
9	7.97E-02	-1.01E-03	3.03E-04	2.02E-05	-6.49E+02	2.13E-05	5.00E+00	4.33E+05	0.00E+00	4»	.92E+05	1.10E+05
10	6.23E-02	-1.15E-03	3.46E-04	2.02E-05	-7.41E+02	2.13E-05	5.00E+00	5.05E+05	0.00E+00	4»	.92E+05	1.10E+05
11	4.52E-02	-1.26E-03	3.78E-04	2.02E-05	-8.08E+02	2.13E-05	5.00E+00	5.58E+05	1.03E+04	4»	.92E+05	1.10E+05

Locally Deformed State for Segment Number 2

1	4.52E-02	-1.26E-03	3.78E-04	2.02E-05	-8.08E+02	2.13E-05	5.00E+00	5.58E+05	1.03E+04	4»	.92E+05	1.10E+05
2	3.16E-02	-1.32E-03	3.96E-04	2.02E-05	-8.47E+02	2.13E-05	5.00E+00	5.88E+05	2.11E+04	4»	.92E+05	1.10E+05
3	1.96E-02	-1.35E-03	4.06E-04	2.02E-05	-8.70E+02	2.13E-05	5.00E+00	6.06E+05	2.76E+04	4»	.92E+05	1.10E+05
4	9.73E-03	-1.37E-03	4.11E-04	2.02E-05	-8.80E+02	2.13E-05	5.00E+00	6.14E+05	3.05E+04	4»	.92E+05	1.10E+05
5	2.91E-03	-1.38E-03	4.13E-04	2.02E-05	-8.84E+02	2.13E-05	5.00E+00	6.16E+05	3.14E+04	4»	.92E+05	1.10E+05
6	-3.13E-17	-1.38E-03	4.13E-04	2.02E-05	-8.84E+02	2.13E-05	5.00E+00	6.17E+05	3.15E+04	4»	.92E+05	1.10E+05
7	-2.91E-03	-1.38E-03	4.13E-04	2.02E-05	-8.84E+02	2.13E-05	5.00E+00	6.16E+05	3.14E+04	4»	.92E+05	1.10E+05
8	-9.73E-03	-1.37E-03	4.11E-04	2.02E-05	-8.80E+02	2.13E-05	5.00E+00	6.14E+05	3.05E+04	4»	.92E+05	1.10E+05
9	-1.96E-02	-1.35E-03	4.06E-04	2.02E-05	-8.70E+02	2.13E-05	5.00E+00	6.06E+05	2.76E+04	4»	.92E+05	1.10E+05
10	-3.16E-02	-1.32E-03	3.96E-04	2.02E-05	-8.47E+02	2.13E-05	5.00E+00	5.88E+05	2.11E+04	4»	.92E+05	1.10E+05
11	-4.52E-02	-1.26E-03	3.78E-04	2.02E-05	-8.08E+02	2.13E-05	5.00E+00	5.58E+05	1.03E+04	4»	.92E+05	1.10E+05

Locally Deformed State for Segment Number 3

1	-3.01E-04	-1.38E-03	4.13E-04	6.50E-12	-2.50E+03	-2.84E-05	4.54E-06	1.99E+06	5.98E+05	1»	.99E+06	6.98E+05
2	-2.25E-03	-1.38E-03	4.13E-04	6.50E-12	-2.50E+03	-2.84E-05	4.54E-06	1.99E+06	5.98E+05	1»	.99E+06	6.98E+05
3	-4.01E-03	-1.38E-03	4.13E-04	6.50E-12	-2.50E+03	6.45E-06	4.54E-06	1.99E+06	5.98E+05	1»	.99E+06	6.98E+05
4	-5.63E-03	-1.37E-03	4.12E-04	6.50E-12	-2.50E+03	-5.13E-06	4.54E-06	1.99E+06	5.97E+05	1»	.99E+06	6.98E+05
5	-7.13E-03	-1.37E-03	4.12E-04	6.50E-12	-2.49E+03	-1.67E-05	4.54E-06	1.99E+06	5.97E+05	1»	.99E+06	6.98E+05
6	-8.54E-03	-1.37E-03	4.12E-04	6.50E-12	-2.49E+03	-3.99E-05	4.54E-06	1.99E+06	5.96E+05	1»	.99E+06	6.98E+05
7	-9.88E-03	-1.37E-03	4.11E-04	6.50E-12	-2.49E+03	6.62E-06	4.54E-06	1.98E+06	5.95E+05	1»	.99E+06	6.98E+05
8	-1.12E-02	-1.37E-03	4.11E-04	6.50E-12	-2.49E+03	-3.97E-05	4.54E-06	1.98E+06	5.94E+05	1»	.99E+06	6.98E+05
9	-1.25E-02	-1.37E-03	4.10E-04	6.50E-12	-2.48E+03	-4.86E-06	4.54E-06	1.98E+06	5.94E+05	1»	.99E+06	6.98E+05
10	-1.37E-02	-1.37E-03	4.10E-04	6.50E-12	-2.48E+03	-3.96E-05	4.54E-06	1.98E+06	5.93E+05	1»	.99E+06	6.98E+05
11	-1.50E-02	-1.36E-03	4.09E-04	6.50E-12	-2.47E+03	-3.95E-05	4.54E-06	1.97E+06	5.91E+05	1»	.99E+06	6.98E+05

Locally Deformed State for Segment Number 4

1	-4.52E-02	-1.26E-03	3.78E-04	2.02E-05	-8.08E+02	2.13E-05	5.00E+00	5.58E+05	1.03E+04	4»	.92E+05	1.10E+05
2	-6.23E-02	-1.15E-03	3.46E-04	2.02E-05	-7.41E+02	2.13E-05	5.00E+00	5.05E+05	0.00E+00	4»	.92E+05	1.10E+05
3	-7.97E-02	-1.01E-03	3.03E-04	2.02E-05	-6.49E+02	2.13E-05	5.00E+00	4.33E+05	0.00E+00	4»		

Table 1.37 (6 of 6)

```
.92E+05  1.10E+05
 4 -9.68E-02 -8.37E-04  2.51E-04  2.02E-05 -5.37E+02  2.13E-05  5.00E+00  3.46E+05  0.00E+00  4»
.92E+05  1.10E+05
 5 -1.13E-01 -6.43E-04  1.93E-04  2.02E-05 -4.13E+02  2.13E-05  5.00E+00  2.48E+05  0.00E+00  4»
.92E+05  1.10E+05
 6 -1.28E-01 -4.41E-04  1.32E-04  2.02E-05 -2.83E+02  2.13E-05  5.00E+00  1.47E+05  0.00E+00  4»
.92E+05  1.10E+05
 7 -1.40E-01 -2.48E-04  7.44E-05  2.02E-05 -1.59E+02  2.13E-05  5.00E+00  7.06E+04  0.00E+00  4»
.92E+05  1.10E+05
 8 -1.50E-01 -7.86E-05  2.36E-05  2.02E-05 -5.04E+01  2.13E-05  5.00E+00  7.06E+04  0.00E+00  4»
.92E+05  1.10E+05
 9 -1.58E-01  5.37E-05 -1.61E-05  2.02E-05  3.45E+01  2.13E-05  5.00E+00  7.06E+04  0.00E+00  4»
.92E+05  1.10E+05
10 -1.62E-01  1.38E-04 -4.13E-05  2.02E-05  8.84E+01  2.13E-05  5.00E+00  7.06E+04  0.00E+00  4»
.92E+05  1.10E+05
11 -1.64E-01  1.67E-04 -5.00E-05  2.02E-05  1.07E+02  2.13E-05  5.00E+00  7.06E+04  0.00E+00  4»
.92E+05  1.10E+05

 AVERAGE AXIAL RESULTANT IN SKIN, Nsknave= -473.766022
 NOTE: Nskave includes Nx averaged in skin and stringer base.
 AVERAGE AXIAL RESULTANT OVERALL, Nx(ave)= -1000.
 AVERAGE STRESS RESULTANTS IN STIFFENER PARTS
 FROM LOAD SET A (eigenvalue loads)..
STRINGER  BASE : AXIAL, TRANSVERSE, IN-PLANE SHEAR= -8.6613E+02  2.1273E-05  5.0000E+00
STRINGER  WEB  : AXIAL, TRANSVERSE, IN-PLANE SHEAR= -2.4894E+03 -2.8410E-05  4.5355E-06
STRINGER FLANGE: AXIAL, TRANSVERSE, IN-PLANE SHEAR=  0.0000E+00  0.0000E+00  0.0000E+00
 FROM LOAD SET B (fixed applied loads)..
STRINGER  BASE : AXIAL, TRANSVERSE, IN-PLANE SHEAR=  0.0000E+00  0.0000E+00  0.0000E+00
STRINGER  WEB  : AXIAL, TRANSVERSE, IN-PLANE SHEAR=  0.0000E+00  0.0000E+00  0.0000E+00
STRINGER FLANGE: AXIAL, TRANSVERSE, IN-PLANE SHEAR=  0.0000E+00  0.0000E+00  0.0000E+00
 RESULTANTS FROM THERMAL LOADING:
STRINGER  BASE : AXIAL, TRANSVERSE, IN-PLANE SHEAR=  0.0000E+00  0.0000E+00  0.0000E+00
STRINGER  WEB  : AXIAL, TRANSVERSE, IN-PLANE SHEAR=  0.0000E+00  0.0000E+00  0.0000E+00
STRINGER FLANGE: AXIAL, TRANSVERSE, IN-PLANE SHEAR=  0.0000E+00  0.0000E+00  0.0000E+00
***** END SUBROUTINE KOIT2 (KOITER THEORY POSTBUCKLING) ******
********** END OF NONLINEAR EQUILIBRIUM CALCS.************
```

Table 1.38 (1 of 3)

riks.axial.realstiff.chap17.opm

```
 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.

***** BEGIN SUBROUTINE STRTHK (POSTBUCKLING STRESSES) ******
       External Stringer

      MODULE WITH RECTANGULAR STIFFENER...

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


    EXPLODED VIEW, SHOWING LAYERS and (SEGMENT, NODE) NUMBERS

                                 (3,11)
                                   !
              Layer No. 1 -----> ! <---------- Layer No. k
                                   !
           Layer No. 1-.           !
                        .          !
     Layer No. 1-.        .        !          .-Layer No. 1
                 .         .       !          .
                 .          .    (3,1)         .
     --------------   ====================   ---------------
   (1,1)   .   (1,11)(2,1)   . (2,6)   (2,11)(4,1)   .   (4,11)
            .                .                       .
             .                .                     .
             Layer No. m       Layer No. n     Layer No. m
```

Start calculation of stresses in the panel module depicted above...
(Segment numbering below refers to the **BOTTOMMOST** of the sketches above.)

STRESSES AT CRITICAL NODES IN SEGMENTS OF MODULE...

BUCK. MODE	LOCATION IN PANEL SEG.	NODE	LAYER	Z	WINDING ANGLE	IN-PLANE STRESSES IN MATL COORDS. SIG1	SIG2	SIG12	MODE OF FAILURE	TRANSVERSE » CRACKING (1.0 means i» nactive)	ALLOWABLE STRESS	MATERIAL TYPE
POS	1	1	1	-3.21E-02	0.0	-1.3392E+04	-1.2793E+04	2.4901E+02	no failure	0.0000»	E+00	1
NEG	1	1	1	-3.21E-02	0.0	1.6722E+04	1.2793E+04	-9.3254E+01	no failure	0.0000»	E+00	1
POS	1	1	1	3.21E-02	0.0	1.6722E+04	1.2793E+04	-9.3254E+01	no failure	0.0000»	E+00	1
NEG	1	1	1	3.21E-02	0.0	-1.3392E+04	-1.2793E+04	2.4901E+02	no failure	0.0000»	E+00	1
POS	1	3	1	-3.21E-02	0.0	-1.3841E+04	-1.1923E+04	-1.8895E+03	no failure	0.0000»	E+00	1
NEG	1	3	1	-3.21E-02	0.0	1.4915E+04	1.1922E+04	2.0452E+03	no failure	0.0000»	E+00	1
POS	1	3	1	3.21E-02	0.0	1.4915E+04	1.1923E+04	2.0452E+03	no failure	0.0000»	E+00	1
NEG	1	3	1	3.21E-02	0.0	-1.3841E+04	-1.1922E+04	-1.8895E+03	no failure	0.0000»	E+00	1
POS	1	5	1	-3.21E-02	0.0	-1.5094E+04	-1.0063E+04	-3.6249E+03	no failure	0.0000»	E+00	1
NEG	1	5	1	-3.21E-02	0.0	1.0131E+04	1.0063E+04	3.7807E+03	no failure	0.0000»	E+00	1
POS	1	5	1	3.21E-02	0.0	1.0131E+04	1.0063E+04	3.7807E+03	no failure	0.0000»	E+00	1
NEG	1	5	1	3.21E-02	0.0	-1.5094E+04	-1.0063E+04	-3.6249E+03	no failure	0.0000»	E+00	1
POS	1	7	1	-3.21E-02	0.0	-1.6270E+04	-7.0182E+03	-4.9215E+03	no failure	0.0000»	E+00	1

Table 1.38 (2 of 3)

NEG	1	7	1	-3.21E-02	0.0	3.4145E+03	7.0177E+03	5.0772E+03	no failure	0.0000»
E+00				1						
POS	1	7	1	3.21E-02	0.0	3.4147E+03	7.0182E+03	5.0772E+03	no failure	0.0000»
E+00				1						
NEG	1	7	1	3.21E-02	0.0	-1.6270E+04	-7.0177E+03	-4.9215E+03	no failure	0.0000»
E+00				1						
POS	1	9	1	-3.21E-02	0.0	-1.6428E+04	-2.8577E+03	-5.5535E+03	no failure	0.0000»
E+00				1						
NEG	1	9	1	-3.21E-02	0.0	-3.7901E+03	2.8572E+03	5.7093E+03	no failure	0.0000»
E+00				1						
POS	1	9	1	3.21E-02	0.0	-3.7899E+03	2.8577E+03	5.7093E+03	no failure	0.0000»
E+00				1						
NEG	1	9	1	3.21E-02	0.0	-1.6428E+04	-2.8572E+03	-5.5535E+03	no failure	0.0000»
E+00				1						
POS	1	11	1	-3.21E-02	0.0	-1.5008E+04	2.2690E+03	-5.2712E+03	no failure	0.0000»
E+00				1						
NEG	1	11	1	-3.21E-02	0.0	-1.0173E+04	-2.2690E+03	5.4270E+03	no failure	0.0000»
E+00				1						
POS	1	11	1	3.21E-02	0.0	-1.0173E+04	-2.2690E+03	5.4270E+03	no failure	0.0000»
E+00				1						
NEG	1	11	1	3.21E-02	0.0	-1.5008E+04	2.2690E+03	-5.2712E+03	no failure	0.0000»
E+00				1						
POS	2	1	1	-3.21E-02	0.0	-1.5007E+04	2.2704E+03	-5.2712E+03	no failure	0.0000»
E+00				1						
NEG	2	1	1	-3.21E-02	0.0	-1.0173E+04	-2.2704E+03	5.4270E+03	no failure	0.0000»
E+00				1						
POS	2	1	1	3.21E-02	0.0	-1.0173E+04	-2.2704E+03	5.4270E+03	no failure	0.0000»
E+00				1						
NEG	2	1	1	3.21E-02	0.0	-1.5007E+04	2.2704E+03	-5.2712E+03	no failure	0.0000»
E+00				1						
POS	2	6	1	-3.21E-02	0.0	-8.0877E+03	1.8931E+04	-1.0268E+03	no failure	0.0000»
E+00				1						
NEG	2	6	1	-3.21E-02	0.0	-1.9446E+04	-1.8931E+04	1.1826E+03	no failure	0.0000»
E+00				1						
POS	2	6	1	3.21E-02	0.0	-1.9446E+04	-1.8931E+04	1.1826E+03	no failure	0.0000»
E+00				1						
NEG	2	6	1	3.21E-02	0.0	-8.0877E+03	1.8931E+04	-1.0268E+03	no failure	0.0000»
E+00				1						
POS	2	11	1	-3.21E-02	0.0	-1.0173E+04	-2.2704E+03	-5.2712E+03	no failure	0.0000»
E+00				1						
NEG	2	11	1	-3.21E-02	0.0	-1.5007E+04	2.2704E+03	5.4270E+03	no failure	0.0000»
E+00				1						
POS	2	11	1	3.21E-02	0.0	-1.5007E+04	2.2704E+03	5.4270E+03	no failure	0.0000»
E+00				1						
NEG	2	11	1	3.21E-02	0.0	-1.0173E+04	-2.2704E+03	-5.2712E+03	no failure	0.0000»
E+00				1						
POS	3	1	1	-9.07E-02	0.0	-1.2281E+04	4.7578E+03	-3.1225E+03	no failure	0.0000»
E+00				2						
NEG	3	1	1	-9.07E-02	0.0	-1.5253E+04	-4.7578E+03	3.1225E+03	no failure	0.0000»
E+00				2						
POS	3	1	1	9.07E-02	0.0	-1.5253E+04	-4.7578E+03	3.1225E+03	no failure	0.0000»
E+00				2						
NEG	3	1	1	9.07E-02	0.0	-1.2281E+04	4.7578E+03	-3.1225E+03	no failure	0.0000»
E+00				2						

```
 Maximum in-plane tensile force in stringer web
 tending to peel the faying flange from the panel skin:
 ********* STRINGER POPOFF MARGIN **********
  Segment number in the discretized model   =  3
  Nodal point number in the discrete model =  1
  Peel force that varies axially as cos(nx)=  2.5902E+02
  Peel force that varies axially as sin(nx)=  2.5902E+02
  Peel force used in popoff constraint,FPOP=  7.7707E+01
 Maximum allowable peel force, FPOPMAX      =  1.0000E+06
 Stringer popoff margin=FPOPMAX/FPOP - 1.0 =  1.2868E+04
 ******* END OF STRINGER POPOFF CALCULATIONS *******
```

POS	3	6	1	-9.07E-02	0.0	-1.1462E+04	2.0327E+03	-2.0962E+03	no failure	0.0000»
E+00				2						
NEG	3	6	1	-9.07E-02	0.0	-1.5988E+04	-2.0327E+03	2.0962E+03	no failure	0.0000»
E+00				2						
POS	3	6	1	9.07E-02	0.0	-1.5988E+04	-2.0327E+03	2.0962E+03	no failure	0.0000»
E+00				2						
NEG	3	6	1	9.07E-02	0.0	-1.1462E+04	2.0327E+03	-2.0962E+03	no failure	0.0000»
E+00				2						
POS	3	11	1	-9.07E-02	0.0	-1.0715E+04	4.3798E+01	-2.0025E+03	no failure	0.0000»
E+00				2						
NEG	3	11	1	-9.07E-02	0.0	-1.6559E+04	-4.3798E+01	2.0025E+03	no failure	0.0000»

Table 1.38 (3 of 3)

```
 E+00                             2
  POS     3     11     1   9.07E-02    0.0 -1.6559E+04 -4.3798E+01  2.0025E+03   no failure      0.0000»
 E+00                             2
  NEG     3     11     1   9.07E-02    0.0 -1.0715E+04  4.3798E+01 -2.0025E+03   no failure      0.0000»
 E+00                             2
  POS     4      1     1 -3.21E-02    0.0 -1.0173E+04 -2.2690E+03 -5.2712E+03   no failure      0.0000»
 E+00                             1
  NEG     4      1     1 -3.21E-02    0.0 -1.5008E+04  2.2690E+03  5.4270E+03   no failure      0.0000»
 E+00                             1
  POS     4      1     1  3.21E-02    0.0 -1.5008E+04  2.2690E+03  5.4270E+03   no failure      0.0000»
 E+00                             1
  NEG     4      1     1  3.21E-02    0.0 -1.0173E+04 -2.2690E+03 -5.2712E+03   no failure      0.0000»
 E+00                             1
  POS     4      6     1 -3.21E-02    0.0  6.9266E+03  8.6850E+03 -4.3420E+03   no failure      0.0000»
 E+00                             1
  NEG     4      6     1 -3.21E-02    0.0 -1.5753E+04 -8.6850E+03  4.4978E+03   no failure      0.0000»
 E+00                             1
  POS     4      6     1  3.21E-02    0.0 -1.5753E+04 -8.6850E+03  4.4978E+03   no failure      0.0000»
 E+00                             1
  NEG     4      6     1  3.21E-02    0.0  6.9266E+03  8.6850E+03 -4.3420E+03   no failure      0.0000»
 E+00                             1
  POS     4     11     1 -3.21E-02    0.0  1.6722E+04  1.2793E+04 -9.3254E+01   no failure      0.0000»
 E+00                             1
  NEG     4     11     1 -3.21E-02    0.0 -1.3392E+04 -1.2793E+04  2.4901E+02   no failure      0.0000»
 E+00                             1
  POS     4     11     1  3.21E-02    0.0 -1.3392E+04 -1.2793E+04  2.4901E+02   no failure      0.0000»
 E+00                             1
  NEG     4     11     1  3.21E-02    0.0  1.6722E+04  1.2793E+04 -9.3254E+01   no failure      0.0000»
 E+00                             1
  Margin=  4.0521E+01  eff.stress:matl=1,SKN,Dseg=2,node=6,layer=1,z=0.0321; MID.;FS=1.
  Margin=  1.2868E+04  stringer popoff margin:(allowable/actual)-1, web 1  MID.;FS=1.
  Margin=  2.5509E+00  eff.stress:matl=2,STR,Dseg=3,node=11,layer=1,z=0.0907; MID.;FS=1.
  ***** END SUBROUTINE STRTHK (POSTBUCKLING STRESSES) ********
```

Table 1.39

riks.axial.realstiff.chap18.opm

```
 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

 PANEL OVERALL & LOCAL IMPERFECTIONS AND DEFORMATION
 General out-of-roundness of cylindrical panel,WIMPG1 =  0.0000E+00
 General initial buckling modal imperfection amplitude=  0.0000E+00
 General modified imperfection amplitude, Wimp(global)=  0.0000E+00
 Local   initial imperfection amplitude, Wimp(local)  =  6.4203E-03
 Panel (inter-ring) initial imp. amplt., Wimp(panel)  =  1.0000E-10
 Bowing due to temperature effects,      W(residual)  =  0.0000E+00
 Overall (inter-ring in cyl) bowing from pressure ,Wp =  0.0000E+00
 Inter-ring bowing (flat panel) from pressure, WPRESR =  0.0000E+00
 Maximum local "pillowing" between stringers,  WLPRES =  0.0000E+00
 Inter-ring bowing due to postbucking effects, WDELKP =  0.0000E+00
 Amplitude factor for bowing except from press,AMPLIT =  4.6960E+00
 Amplitude factor for bowing due to pressure,  AMPLT2 =  4.6960E+00
 Amplitude factor for inter-ring bowing,       AMPLT3 =  1.0000E+00
 Eccentricity of application of axial loads,     ECC  =  0.0000E+00

 *** BEGIN SUBROUTINE LOCAL (HI-M POST-POSTBUCKLING SEARCH) ***
  LABEL NO. IN STRUCT= 9360

 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
   14      1.00677E+00       1.00000E+00      1.00000E+00       1.00677E+00
   15      1.04732E+00       1.00000E+00      1.00000E+00       1.04732E+00
   14      1.00677E+00       1.00000E+00      1.00000E+00       1.00677E+00
 Buckling load factor from SUB. LOCAL, EIGITR(6)=  1.0068E+00
 Number of axial halfwaves between rings,NPP=   14
  **** END SUBROUTINE LOCAL (HI-M POST-POSTBUCKLING SEARCH) ****

 **** BEGIN SUBROUTINE  MODE (HI-M POST-POSTBUCKLING MODE) ****
  **** END SUBROUTINE  MODE (HI-M POST-POSTBUCKLING MODE) ****
 Margin=  6.7749E-03  Hi-axial-wave post-post-buckling of module - 1;   M=14 ;FS=1.
 ******** THE HI-AXIAL-WAVE POST-POST BUCKL. MARGIN COMPUTED:
Hi-axial-wave post-post-buckling of module - 1;   M=14 ;FS=1.
 ******** CONSTRAINT NO.  6; LOAD SET NO. 1; SUBCASE NO. 1

*** BEGIN SUBROUTINE DEFCIJ (POST-LOCALLY BUCKLED CS(I,J)) ****
 Effective stiffnesses of undeformed and of
 locally deformed module segments:
                                                     Undeformed   Deformed
    Effective axial stiffness of panel SKIN + BASE = 7.0553E+05  3.3991E+05
    Effective hoop  stiffness of panel SKIN + BASE = 7.0553E+05  4.9154E+05
    Effective (1,2) stiffness of panel SKIN + BASE = 2.1166E+05  8.2013E+03
    Effective axial stiffness of stringer   WEB    = 1.9942E+06  1.9856E+06
    Effective axial stiffness of stringer   FLANGE = 0.0000E+00  0.0000E+00
    Effective shear stiffness of panel SKIN + BASE = 2.4694E+05  1.0968E+05
    Effective shear stiffness of stringer   WEB    = 6.9798E+05  6.9798E+05
    Effective shear stiffness of stringer   FLANGE = 0.0000E+00  0.0000E+00

 Integrated stringer stiffnesses...
    Effective axial stiffness of stringer,     STIFL = 3.8212E+05
    Effective first moment, Int[STIF*zdz],     STIFM = 4.1543E+05
    Effective second moment,Int[STIF*z**2dz],STIFMM= 5.9387E+05

 Constitutive law, CS(i,j), for locally deformed
 panel with smeared stringers and rings.....
      7.2614E+05  8.1117E+03  0.0000E+00  4.1543E+05  0.0000E+00  0.0000E+00
      8.1117E+03  4.9154E+05  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
      0.0000E+00  0.0000E+00  1.0968E+05  0.0000E+00  0.0000E+00  0.0000E+00
      4.1543E+05  0.0000E+00  0.0000E+00  5.9412E+05  7.2706E+01  0.0000E+00
      0.0000E+00  0.0000E+00  0.0000E+00  7.2706E+01  2.4235E+02  0.0000E+00
```

note

Table 1.39 (end)

```
    0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  4.8974E+02
*** END   SUBROUTINE DEFCIJ (POST-LOCALLY BUCKLED CS(I,J)) ****
```

Table 1.40

riks.axial.realstiff.chap19.opm

```
 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.).

*** BEGIN SUBROUTINE BUCKLE (WIDE-COLUMN BUCKLING - MODULE) ****
*** END SUBROUTINE BUCKLE (WIDE-COLUMN BUCKLING - MODULE) ****

*** BEGIN SUBROUTINE MODE (WIDE-COLUMN BUCKLING MODE SHAPE) ****
 NUMBER OF AXIAL HALFWAVES =       1
 AMPLITUDE OF BUCKLING MODE AT STRINGER BASE, WSTR   =  8.8045E-01
 AMPLITUDE OF BUCKLING MODE BETWEEN STRINGERS,WSKIN =  1.0000E+00
 RATIO OF BUCKLING MODAL DISPLACEMENTS,   WSTR/WSKIN =  8.8045E-01
 AMPLIT.OF BUCKLING MODE AT STRINGER WEB TIP, WTIP   =  7.9258E-18
 AMPLIT.OF BUCKLING MODE AT STRINGER MIDWEB,  WMID   =  2.0203E-18
 *** END SUBROUTINE MODE (WIDE-COLUMN BUCKLING MODE SHAPE) ****

 WIDE COLUMN BUCKLING (DISCRETE MODULE MODEL)=  1.3470E+00
 WIDE COLUMN BUCKLING (PANDA-TYPE MODEL     )=  1.2706E+00
  DISCRETE MODEL BEING SET EQUAL TO PANDA-TYPE MODEL.

  WIDE COLUMN PANEL BUCKLING LOAD FACTOR =           1.2706E+00
 ISKIN = 0. WIDE COLUMN BUCKLING IS IGNORED IF ISKIN = 1.
 IWIDE = 0. WIDE COLUMN BUCKLING IS IGNORED IF IWIDE = 0.
 ITIP  = 0. MODE OF BUCKLING IS STRINGER SIDESWAY IF ITIP=1
  *** END OF WIDE COLUMN BUCKLING CALCULATIONS ***
```

we do not use the "wide column" model in this case.

Table 1.41

riks.axial.realstiff.chap20.opm

```
 ****************************************************************
 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].

 EXPLANATION OF FOLLOWING CALC. (LOAD SET NO. 1):
     Next, the load factor for m=?? lateral-torsional buckling
     is computed from the discretized panel module model. The
     analysis takes into account local deformation of the
     panel module cross section, the redistribution of axial
     stress resultants Nx over the discretized module cross
     section, and the axial "softening" of a locally post-
     buckled skin-stringer discretized module.

 Effective axial length of the panel,          AXLEN2=  5.0000E+01
 LATERAL-TORSIONAL BUCKLING: Search for critical load...
 Number of axial halfwaves=  1; Buckling load factor=  2.4724E+00

 NUMBER OF AXIAL HALFWAVES =        1
 AMPLITUDE OF BUCKLING MODE AT STRINGER BASE, WSTR   =  9.5198E-09
 AMPLITUDE OF BUCKLING MODE BETWEEN STRINGERS,WSKIN =  1.0000E+00
 RATIO OF BUCKLING MODAL DISPLACEMENTS,   WSTR/WSKIN =  9.5198E-09
 AMPLIT.OF BUCKLING MODE AT STRINGER WEB TIP, WTIP   =  7.3842E-01
 AMPLIT.OF BUCKLING MODE AT STRINGER MIDWEB,   WMID  =  3.7471E-01
 Number of axial halfwaves=  2; Buckling load factor=  1.3509E+00

 NUMBER OF AXIAL HALFWAVES =        2
 AMPLITUDE OF BUCKLING MODE AT STRINGER BASE, WSTR   =  3.6169E-13
 AMPLITUDE OF BUCKLING MODE BETWEEN STRINGERS,WSKIN =  1.0000E+00
 RATIO OF BUCKLING MODAL DISPLACEMENTS,   WSTR/WSKIN =  3.6169E-13
 AMPLIT.OF BUCKLING MODE AT STRINGER WEB TIP, WTIP   =  6.4926E-01
 AMPLIT.OF BUCKLING MODE AT STRINGER MIDWEB,   WMID  =  3.3092E-01
 Number of axial halfwaves=  3; Buckling load factor=  1.1078E+00

 NUMBER OF AXIAL HALFWAVES =        3
 AMPLITUDE OF BUCKLING MODE AT STRINGER BASE, WSTR   =  6.5310E-16
 AMPLITUDE OF BUCKLING MODE BETWEEN STRINGERS,WSKIN =  1.0000E+00
 RATIO OF BUCKLING MODAL DISPLACEMENTS,   WSTR/WSKIN =  6.5310E-16
 AMPLIT.OF BUCKLING MODE AT STRINGER WEB TIP, WTIP   =  5.3484E-01
 AMPLIT.OF BUCKLING MODE AT STRINGER MIDWEB,   WMID  =  2.7472E-01
 Number of axial halfwaves=  4; Buckling load factor=  9.9091E-01

 NUMBER OF AXIAL HALFWAVES =        4
 AMPLITUDE OF BUCKLING MODE AT STRINGER BASE, WSTR   =  4.2289E-16
 AMPLITUDE OF BUCKLING MODE BETWEEN STRINGERS,WSKIN =  1.0000E+00
 RATIO OF BUCKLING MODAL DISPLACEMENTS,   WSTR/WSKIN =  4.2289E-16
 AMPLIT.OF BUCKLING MODE AT STRINGER WEB TIP, WTIP   =  4.2514E-01
 AMPLIT.OF BUCKLING MODE AT STRINGER MIDWEB,   WMID  =  2.2090E-01
 Margin=  7.0817E-03  (m=3   lateral-torsional buckling load factor)/(FS)-1;FS=1.1
 *** THE LATERAL-TORSIONAL BUCKLING MARGIN JUST COMPUTED:
(m=3   lateral-torsional buckling load factor)/(FS)-1;FS=1.1
 ******* CONSTRAINT NO.  7; LOAD SET NO. 1; SUBCASE NO. 1
 LATERAL-TORSIONAL BUCKLING LOAD FACTOR =        1.1078E+00
 *** END OF LATERAL-TORSIONAL BUCKLING CALCULATIONS ***
```

This mode is judged by PANDA2 to be a form of local skin buckling rather than "lateral-torsional" buckling because the stringer tip sidesway (WTIP) is less than 1/2 the amplitude of the skin deflection, WSKIN.

Table 1.42

```
riks.axial.realstiff.chap23.opm

 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.

 ***** BEGIN SUBROUTINE STRCON (IQUICK = 1 TYPE STRESSES) ******
       External Stringer

      MODULE WITH RECTANGULAR STIFFENER...

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


   EXPLODED VIEW, SHOWING LAYERS and (SEGMENT, NODE) NUMBERS

                                  (3,11)
                                     !
             Layer No. 1 -----> ! <---------- Layer No. k
                                     !
         Layer No. 1-.                !
                        .             !
   Layer No. 1-.          .          !           .-Layer No. 1
                 .          .         !            .
                 .            .   (3,1)              .
   --------------     ====================     --------------
 (1,1)    .    (1,11)(2,1)     . (2,6)     (2,11)(4,1)   .    (4,11)
            .                 .                            .
             .                  .                            .
               Layer No. m        Layer No. n     Layer No. m

 Start calculation of stresses in the panel module depicted above...
 (Segment numbering below refers to the **TOPMOST** of the sketches above.)
 SEG.NODE LAYER  THICKNESS  WINDING   IN-PLANE STRESSES IN MATL COORDS.  MATERIAL    MODE OF   »
  TRANSVERSE  ALLOWABLE  MATL
 NO.  NO.  NO.  COORDINATE   ANGLE        SIG1         SIG2         SIG12      STATUS     FAILURE   »
   CRACKING     STRESS     TYPE
                 (z)        (deg)                                                                   (1.»
0 means inactive)
  positive imperfection factor
  skin-stringer module stresses:
   Stresses from sinxsiny or cosxcosy deformations (at peaks and valleys):
  SKN 1       1 -3.2102E-02  0.0000E+00 -8.6601E+02  8.8840E+03  7.7878E+01    OK       no failur»
e      1.000                 1
  SKN 1       1  3.2102E-02  0.0000E+00 -1.8634E+04 -8.8840E+03  7.7878E+01    OK       no failur»
e      1.000                 1
   Stresses from sinxcosy or cosxsiny deformations (at nodal lines):
  SKN 1       1 -3.2102E-02  0.0000E+00 -9.7500E+03  4.4796E-04 -4.7058E+03    OK       no failur»
e      1.000                 1
  SKN 1       1  3.2102E-02  0.0000E+00 -9.7500E+03  4.4796E-04  4.8616E+03    OK       no failur»
e      1.000                 1
  STR 2       1 -3.2102E-02  0.0000E+00 -9.7500E+03  4.4796E-04 -4.7058E+03    OK       no failur»
e      1.000                 1
  STR 2       1  3.2102E-02  0.0000E+00 -9.7500E+03  4.4796E-04  4.8616E+03    OK       no failur»
e      1.000                 1
  STR 3 ROOT 1  0.0000E+00  0.0000E+00 -9.7500E+03 -1.9169E-04  2.4992E-05    OK       no failur»
e      1.000                 2
  STR 3 TIP  1  0.0000E+00  0.0000E+00 -9.7500E+03  1.9210E-04  2.4992E-05    OK       no failur»
e      1.000                 2
  negative imperfection factor
  skin-stringer module stresses:
   Stresses from sinxsiny or cosxcosy deformations (at peaks and valleys):
  SKN 1       1 -3.2102E-02  0.0000E+00 -1.8634E+04 -8.8840E+03  7.7878E+01    OK       no failur»
e      1.000                 1
  SKN 1       1  3.2102E-02  0.0000E+00 -8.6601E+02  8.8840E+03  7.7878E+01    OK       no failur»
e      1.000                 1
```

Table 1.42 (end)

```
 Stresses from sinxcosy or cosxsiny deformations (at nodal lines):
 SKN 1       1 -3.2102E-02  0.0000E+00 -9.7500E+03  4.4796E-04  4.8616E+03     OK        no failur»
e     1.000                 1
 SKN 1       1  3.2102E-02  0.0000E+00 -9.7500E+03  4.4796E-04 -4.7058E+03     OK        no failur»
e     1.000                 1
 STR 2       1 -3.2102E-02  0.0000E+00 -9.7500E+03  4.4796E-04  4.8616E+03     OK        no failur»
e     1.000                 1
 STR 2       1  3.2102E-02  0.0000E+00 -9.7500E+03  4.4796E-04 -4.7058E+03     OK        no failur»
e     1.000                 1
 STR 3 ROOT 1  0.0000E+00   0.0000E+00 -9.7500E+03 -1.9169E-04  2.4992E-05     OK        no failur»
e     1.000                 2
 STR 3 TIP  1  0.0000E+00   0.0000E+00 -9.7500E+03  1.9210E-04  2.4992E-05     OK        no failur»
e     1.000                 2
 Margin=  6.0943E+01  eff.stress:matl=1,SKN,Iseg=1,allnode,layer=1,z=-0.0321;-MID.;FS=1.
 Margin=  5.1539E+00  eff.stress:matl=2,STR,Iseg=3,at:TIP,layer=1,z=0.;-MID.;FS=1.
 ***** END   SUBROUTINE STRCON (IQUICK = 1 TYPE STRESSES) ******
  **** END OF STRESS CALCULATIONS ***
```

Table 1.43

```
riks.axial.realstiff.chap25.opm

 ************************************************************
 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].

***** BEGIN SUBROUTINE STFEIG (BUCKLING IN STIFFENERS) ******
 ENTERING STFEIG: MIDEND=     1
 IMOD= 0, Wavenumbers: MSKIN=     5, NSKIN=     1
```

including effect of local post-buckling of skin

```
 STRINGER:

 ***  BUCKLING (short wavelength buckling) of parts of the panel module cross section perpendicu»
lar to generator ***
 NOTE: The segment numbering scheme used here corresponds to
       that used when the user provides input data.  It may
       differ from that used for the discretized module model.
       Please see ITEM 272 in the file panda2/doc/panda2.news.
 STIFFENER   MODULE     PRELOAD      RESULTANT   BUCKLING         BUCKLING      NO. OF BUCKLING      »
    COMMENT
   TYPE      SEGMENT     RESULTANT     FROM LOAD  LOAD FACTOR     LOAD FACTOR       HALFWAVES
                        (LOAD SET B)     SET A   (no transverse (with transverse   BETWEEN
                         (average)      (ave.)    shear deform.) shear deform.)   STIFFENERS
 Prebuck.resultant along stringer axis at root and tip of web:
   At root of web: -2.4983E+03;   At tip of web: -2.4748E+03
 Knockdown factor to account for in-plane shearing of web and
   any anisotropic properties of the web, FKNOCK(5)=  1.0000E+00

 Entering CRIPPL:
 Eigenvalue preload at web root and tip= -2.4983E+03 -2.4748E+03
 Fixed      preload at web root and tip=  0.0000E+00  0.0000E+00
 M = SQRT(SQRT((EFOUND+C(5,5)*FACT**2)/C(4,4)))*A0/3.1415927=      5
 IN SUB. ENDBUK: EIG=  2.2915E+00
 In CRIPPL, before SHRRED: LAMBDA,SHRLOD,T,GT(1),GT(2)=
  2.2915E+00 -2.4894E+03  1.8147E-01  3.8460E+06  3.8460E+06
 ISEG,ISRIDY,NMINSR,NWAVE,NMAXSR,FKNOCK=     3     1     6     5     8  1.0000E+00
 NOTE: If FKNOCK is less than 0.99 the stringer web buckling
       WILL be recorded as a margin even if the critical number
       of axial halfwaves lies within the range, NMINSR - NMAXSR
 Margin=  1.2915E+00  buckling margin stringer Iseg.3 . Local halfwaves=5  .MID.;FS=1.
  stringer     3     0.0000E+00  -2.4894E+03    2.2915E+00                       5
```

Note: no overall axial bending in the PANDA2 model in this case

stiffener buckling load factor

```
 RING:
 ***** END   SUBROUTINE STFEIG (BUCKLING IN STIFFENERS) ******
  LABEL NO. IN STRUCT= 9565

***** BEGIN SUBROUTINE STFEIG (NO POSTBUCKLING EFFECT) ******
 ENTERING STFEIG: MIDEND=     1
 IMOD= 0, Wavenumbers: MSKIN=     5, NSKIN=     1
```

neglecting effect of local post-buckling of panel skin

```
 STRINGER:

 ***  BUCKLING (short wavelength buckling) of parts of the panel module cross section perpendicu»
lar to generator ***
 NOTE: The segment numbering scheme used here corresponds to
       that used when the user provides input data.  It may
       differ from that used for the discretized module model.
       Please see ITEM 272 in the file panda2/doc/panda2.news.
 STIFFENER   MODULE     PRELOAD      RESULTANT   BUCKLING         BUCKLING      NO. OF BUCKLING      »
    COMMENT
   TYPE      SEGMENT     RESULTANT     FROM LOAD  LOAD FACTOR     LOAD FACTOR       HALFWAVES
                        (LOAD SET B)     SET A   (no transverse (with transverse   BETWEEN
                         (average)      (ave.)    shear deform.) shear deform.)   STIFFENERS
 Prebuck.resultant along stringer axis at root and tip of web:
   At root of web: -1.7694E+03;   At tip of web: -1.7694E+03
 Knockdown factor to account for in-plane shearing of web and
   any anisotropic properties of the web, FKNOCK(5)=  1.0000E+00

 Entering CRIPPL:
 Eigenvalue preload at web root and tip= -1.7694E+03 -1.7694E+03
```

less load in stringer because of neglect of load shedding by post-buckled skin.

Table 1.43(end)

```
Fixed      preload at web root and tip=  0.0000E+00  0.0000E+00
M = SQRT(SQRT((EFOUND+C(5,5)*FACT**2)/C(4,4)))*A0/3.1415927=      5
IN SUB. ENDBUK: EIG=  3.2126E+00
In CRIPPL, before SHRRED: LAMBDA,SHRLOD,T,GT(1),GT(2)=
 3.2126E+00 -1.7694E+03  1.8147E-01  3.8460E+06  3.8460E+06
ISEG,ISRIDY,NMINSR,NWAVE,NMAXSR,FKNOCK=    3    1    6    5    8  1.0000E+00
NOTE: If FKNOCK is less than 0.99 the stringer web buckling
      WILL be recorded as a margin even if the critical number
      of axial halfwaves lies within the range, NMINSR - NMAXSR
Margin=  2.2126E+00  buckling margin stringer Iseg.3 . Local halfwaves=5  .NOPO;FS=1.
 stringer     3      0.0000E+00  -1.7694E+03   3.2126E+00                        5


RING:
******* END SUBROUTINE STFEIG (NO POSTBUCKLING EFFECT) ******
 *** END OF STIFFENER SEGMENT BUCKLING (if any) ****
```

Table 1.44

```
riks.axial.realstiff.chap26.opm

 ***********************************************************
 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.

*** BEGIN SUBROUTINE BUCPAN (PANDA-TYPE BUCKLING LOADS) ****

 Local buckling, C11=  2.3544E+05, radius, R=  7.0711E+05
 ******** ENTERING GENSTB: PANDA-type buckling model ********
 PANDA-type buckling theory is described in the journal paper:
 D. Bushnell, "Theoretical basis of the PANDA computer program"
 Computers & Structures, Vol. 27, No. 4, pp. 541-563, 1987
 Also see Items 415 and 443 in ...panda2/doc/panda2.news.
 Initial imperfections for general, panel, local buckling=
 Total out-of-roundness + modal,     W0GLOB =  1.0000E-10
 Out-of-roundness,                      WG1  =  0.0000E+00
 General buckling modal,                WG2  =  0.0000E+00
 Inter-ring buckling modal,           W0PAN =  1.0000E-10
 Local buckling modal,                W0LOC =  1.0000E-02
 ***** NOTE: Panel is modelled as if it were flat. *****
 ***** Donnell theory is used in this section (ISAND=0)

 Load Set A: Nx,  Ny,  Nxy= -3.0561E+02  2.1273E-05  5.0000E+00
 Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00

 Test for direction panel is long: TEST=(A/B)*SQRT(C55N/(C44N*C44MLT))=5.00E+00
 If TEST > 0.99 then d = 0;  c = SLOPE (panel is long in x-direction, Fig.(9a).
 If TEST < 0.99 then d = SLOPE; c = 0. (panel is long in y-direction, Fig.(9b).
 See Eq.(51) and Fig. 9 of "Theoretical basis..." paper (1987).

 EIGMNC=  6.58E-01  1.00E+17  3.13E-01  1.00E+17  1.00E+17  2.11E+00  1.00E+17
 SLOPEX=  2.00E-02  0.00E+00  1.00E-02  0.00E+00  0.00E+00  7.00E-02  0.00E+00
 MWAVEX=     2         0         5         0         0         1         0
 NWAVEX=     1         0         1         0         0         1         0
 TESTX =  5.00E+00  0.00E+00  5.00E+00  0.00E+00  0.00E+00  5.00E+00  0.00E+00
 Before refinement (before CALL EIG), EIGVAL,CSLOPE=  3.1303E-01  1.0000E-02
  After refinement ( after CALL EIG), EIGVAL,CSLOPE=  3.1303E-01  1.0000E-02
 NOTE: The buckling nodal line slopes, SLOPEX, are as
 defined in Fig. 9a or Fig. 9b of the 1987 "Theoretical
 basis of the PANDA...",if NWAVEX > 0; that is, there
 has not yet been any inversion of SLOPEX when 9b holds.

 LOCAL BUCKLING FROM PANDA-TYPE THEORY [1B] AFTER KNOCKDOWN FOR t.s.d.:
 EIGLOC =   3.1303E-01(m=   5,n=   1)
```

lowest eigenvalue & mode shape for local buckling

```
 general buckling: smeared stiffeners, C11=  7.2614E+05, radius, R=  7.0711E+05
 ******** ENTERING GENSTB: PANDA-type buckling model ********
 ***** Donnell theory is used in this section (ISAND=0)
 Load Set A: Nx,  Ny,  Nxy= -1.0000E+03  0.0000E+00  5.0000E+00
 Load Set B: Nxo, Nyo, Nxyo=  0.0000E+00  0.0000E+00  0.0000E+00

 EIGMNC=  1.52E+00  1.80E+00  1.52E+00  1.00E+17  1.00E+17  1.52E+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         1         0         0         1         0
 NWAVEX=     1         2         1         0         0         1         0
 TESTX =  2.61E-02  2.61E-02  2.61E-02  0.00E+00  0.00E+00  2.61E-02  0.00E+00
 Before refinement (before CALL EIG), EIGVAL,CSLOPE=  1.5164E+00  0.0000E+00
  After refinement ( after CALL EIG), EIGVAL,CSLOPE=  1.5164E+00  0.0000E+00

 General buckling loads AFTER knockdown for t.s.d.
 Number of circumferential halfwaves in buckling pattern=  1.0000E+00
 Buckling load factor BEFORE knockdown for smeared stringers=  1.5164E+00
 Buckling load factor AFTER  knockdown for smeared stringers=  1.0994E+00

 General buckling load factor before and after knockdown:
 EIGGEN(before modification by 5 factors below)      =  1.0994E+00
 Knockdown factor from modal imperfection(s)         =  1.0000E+00
 Knockdown factor for smearing rings on cyl. shell   =  1.0000E+00
 Knockup factor to avoid twice accounting for t.s.d.=  1.0000E+00
 1st modifying factor, FKNMOD=1 or 1/(EIG9X*FMDKD9)  =  1.0000E+00
 2nd modifying factor, EIGMR9=1 or EIGGNX/EIGGEN     =  1.0000E+00
 After knockdn,EIGGEN*FKNOCK(9)*(RNGKNK/SHRFCT)*FKNMOD*EIGMR9=  1.0994E+00
 in which
 EIG9X  = lambda(ARBOCZ)/lambda(original PANDA-type theory)=  1.0000E+00
```

lowest eigenvalue & mode shape for general buckling

Table 1.44 (end)

```
        lambda(ARBOCZ)=perfect panel buckling from ARBOCZ theory
        lambda(PANDA) =perfect panel buckling from PANDA  theory
  FMDKD9 = 1 or 0.9/EIG9X =  0.0000E+00
  EIGGNX = eigenvalue for perfect panel from alternate solution
     12      1.09942E+00   buckling load factor simp-support general buck;M=1;N=1;slope=0.
  Margin= -5.2321E-04  buck.(DONL);simp-support general buck;M=1;N=1;slope=0.;FS=1.1
```

Table 1.45

riks.axial.realstiff.chap28.opm

```
 CHAPTER 28 Present design, loading, and margins for the
            current load set and subcase. See Table 6 in
 Bushnell, D.
 "Optimization of an axially compressed ring and stringer
 stiffened cylindrical shell with a general buckling modal
 imperfection", AIAA Paper 2007-2216, 48th AIAA SDM Meeting,
 Honolulu, Hawaii, April 2007
0
           SUMMARY OF INFORMATION FROM OPTIMIZATION ANALYSIS
 VAR. DEC. ESCAPE LINK. LINKED  LINKING    LOWER    CURRENT     UPPER       DEFINITION
  NO. VAR.  VAR.  VAR.    TO   CONSTANT    BOUND     VALUE      BOUND
   1   N     N     N      0    0.00E+00  0.00E+00 1.0000E+01  0.00E+00        B(STR):stiffener s»
pacing, b: STR seg=NA, layer=NA
   2   N     N     N      0    0.00E+00  0.00E+00 3.0000E+00  0.00E+00       B2(STR):width of st»
ringer base, b2 (must be > 0, see
   3   Y     N     N      0    0.00E+00  2.00E-01 2.1139E+00  1.00E+01        H(STR):height of s»
tiffener (type H for sketch), h:
   4   Y     Y     N      0    0.00E+00  1.00E-02 6.4203E-02  1.00E+00    T(1 )(SKN):thickness f»
or layer index no.(1 ): SKN seg=1
   5   Y     Y     N      0    0.00E+00  1.00E-02 1.8147E-01  1.00E+00    T(2 )(STR):thickness f»
or layer index no.(2 ): STR seg=3
 BUCKLING LOAD FACTORS FOR LOCAL BUCKLING FROM KOITER v. BOSOR4 THEORY:
  Local buckling load factor from KOITER theory =  2.5843E-01 (flat skin)
  Local buckling load factor from BOSOR4 theory =  2.6252E-01 (flat skin)

 *********** LOAD SET NO. 1  **************
 ICASE =  1  (ICASE=1 MEANS PANEL MIDLENGTH)
             (ICASE=2 MEANS PANEL ENDS                          )

   APPLIED LOADS IN LOAD SET A ("eigenvalue" loads):
         Applied     axial        stress resultant, Nx= -1.0000E+03
         Applied circumferential stress resultant, Ny=  0.0000E+00
         Applied    in-plane      shear  resultant,Nxy=  5.0000E+00
         Applied     axial        moment resultant, Mx=  0.0000E+00
         Applied circumferential moment resultant, My=  0.0000E+00
         Applied pressure (positive for upward),    p =  0.0000E+00

   APPLIED LOADS IN LOAD SET B ( fixed uniform loads):
         Applied     axial        stress resultant,Nx0=  0.0000E+00
         Applied circumferential stress resultant,Ny0=  0.0000E+00
         Applied    in-plane     shear  resultant,Nxy0=  0.0000E+00

 NOTE: "F.S." means "Factor of Safety";
 "DONL" means "Donnell shell theory used.";
 "SAND" means "Sanders shell theory used." panda2.news ITEM 128
 "Dseg" means "Segment numbering used in discretized model"
 "Iseg" means "Segment numbering used for input data." ITEM 272
0
 MARGINS FOR CURRENT DESIGN: LOAD CASE NO. 1, SUBCASE NO. 1
 MAR. MARGIN
 NO.  VALUE                 DEFINITION
 1   3.13E-01 Local buckling from discrete model-1.,M=7   axial halfwaves;FS=0.2
 2   2.92E-01 Local buckling from Koiter theory,M=7   axial halfwaves;FS=0.2
 3   4.05E+01 eff.stress:matl=1,SKN,Dseg=2,node=6,layer=1,z=0.0321; MID.;FS=1.
 4   1.29E+04 stringer popoff margin:(allowable/actual)-1, web 1  MID.;FS=1.
 5   2.55E+00 eff.stress:matl=2,STR,Dseg=3,node=11,layer=1,z=0.0907; MID.;FS=1.
 6   6.77E-03 Hi-axial-wave post-post-buckling of module - 1;   M=14 ;FS=1.
 7   7.08E-03 (m=3   lateral-torsional buckling load factor)/(FS)-1;FS=1.1
 8   6.09E+01 eff.stress:matl=1,SKN,Iseg=1,allnode,layer=1,z=-0.0321;-MID.;FS=1.
 9   5.15E+00 eff.stress:matl=2,STR,Iseg=3,at:TIP,layer=1,z=0.;-MID.;FS=1.
10   1.29E+00 buckling margin stringer Iseg.3 . Local halfwaves=5  .MID.;FS=1.
11   2.21E+00 buckling margin stringer Iseg.3 . Local halfwaves=5  .NOPO;FS=1.
12  -5.23E-04 buck.(DONL);simp-support general buck;M=1;N=1;slope=0.;FS=1.1
13   3.66E+00 buck.(DONL);rolling only of stringers;M=14;N=0;slope=0.;FS=1.4
14   7.25E+02 (Max.allowable ave.axial strain)/(ave.axial strain) -1; FS=1.
15   1.11E-01 0.3333 *(Stringer spacing, b)/(Stringer base width, b2)-1;FS=1.
16  -5.23E-04 buck.(SAND);simp-support general buck;M=1;N=1;slope=0.;FS=1.1
 ***********  ALL 1 LOAD SETS PROCESSED  ***********
 ****************************************************

0
           SUMMARY OF INFORMATION FROM OPTIMIZATION ANALYSIS
 VAR. DEC. ESCAPE LINK. LINKED  LINKING    LOWER    CURRENT     UPPER       DEFINITION
  NO. VAR.  VAR.  VAR.    TO   CONSTANT    BOUND     VALUE      BOUND
   1   N     N     N      0    0.00E+00  0.00E+00 1.0000E+01  0.00E+00        B(STR):stiffener s»
```

optimum design

See Table 1.35

→ " = "most critical margins"

Table 1.45 (end)

```
pacing, b: STR seg=NA, layer=NA
   2   N     N     N      0    0.00E+00   0.00E+00 3.0000E+00   0.00E+00        B2(STR):width of st»
ringer base, b2 (must be > 0, see
   3   Y     N     N      0    0.00E+00   2.00E-01 2.1139E+00   1.00E+01         H(STR):height of s»
tiffener (type H for sketch), h:
   4   Y     Y     N      0    0.00E+00   1.00E-02 6.4203E-02   1.00E+00    T(1 )(SKN):thickness f»
or layer index no.(1 ): SKN seg=1
   5   Y     Y     N      0    0.00E+00   1.00E-02 1.8147E-01   1.00E+00    T(2 )(STR):thickness f»
or layer index no.(2 ): STR seg=3

 ***************************************************
 ******************* DESIGN OBJECTIVE *******************
 *************                             ***********
0
   CURRENT VALUE OF THE OBJECTIVE FUNCTION:
 VAR. STR/ SEG. LAYER   CURRENT
 NO.  RNG  NO.   NO.     VALUE            DEFINITION
            0     0    2.564E+01   WEIGHT OF THE ENTIRE PANEL

  TOTAL WEIGHT OF SKIN                                =   1.6051E+01
  TOTAL WEIGHT OF SUBSTIFFENERS                       =   0.0000E+00
  TOTAL WEIGHT OF STRINGERS                           =   9.5903E+00
  TOTAL WEIGHT OF RINGS                               =   0.0000E+00
  SPECIFIC WEIGHT (WEIGHT/AREA) OF STIFFENED PANEL=   1.0256E-02

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

Table 1.46 riks.STG ~~(riks.axial.realstiff.5bay.stg)~~ (riks.linear.deformableedgeo.~~pdf~~stg)

```
n          $ Do you want a tutorial session and tutorial output?
   1       $ Choose type of STAGS analysis (1,3,4,5,6),INDIC
   0       $ Restart from ISTARTth load step (0=1st nonlinear soln), ISTART
0.2600000  $ Local buckling load factor from PANDA2, EIGLOC
 y         $ Are the dimensions in this case in inches?
   0       $ Nonlinear (0) or linear (1) kinematic relations?, ILIN
   0       $ Type 1 for closed (360-deg) cyl. shell, 0 otherwise, ITOTAL
  50       $ X-direction length of the STAGS model of the panel: XSTAGS
  50       $ Panel length in the plane of the screen, L2
 y         $ Is the nodal point spacing uniform along the stringer axis?
  51       $ Number of nodes in the X-direction: NODEX
-1000.     $ Resultant (e.g. lb/in) normal to the plane of screen, Nx
   0       $ Resultant (e.g. lb/in) in the plane of the screen,    Ny
   0       $ In-plane shear in load set A,                   Nxy
   0       $ Normal pressure in STAGS model in Load Set A, p
   0       $ Resultant (e.g. lb/in) normal to the plane of screen, Nx0
   0       $ Resultant (e.g. lb/in) in the plane of the screen,    Ny0
   0       $ Normal pressure in STAGS model in Load Set B, p0
   1       $ Starting load factor for Load System A, STLD(1)
   0       $ Load factor increment for Load System A, STEP(1)
   1       $ Maximum load factor for Load System A, FACM(1)
   0       $ Starting load factor for Load System B, STLD(2)
   0       $ Load factor increment for Load System B, STEP(2)
   0       $ Maximum load factor for Load System B, FACM(2)
   1       $ How many eigenvalues do you want? NEIGS
 480       $ Choose element type (410 or 411 or 480) for panel skin
 n         $ Have you obtained buckling modes from STAGS for this case?
   6       $ Number of stringers in STAGS model of the flat panel
   0       $ Number of rings in the STAGS model of the panel
 n         $ Are there rings at the ends of the panel?
  10       $ Number of finite elements between adjacent stringers
  25       $ Number of finite elements between adjacent rings
   3       $ Stringer model: 1 or 2 or 3 or 4 or 5(Type H(elp))
   3       $ Ring model: 1 or 2 or 3 or 4 or 5 (Type H(elp))
   0       $ Reference surface of cyl: 1=outer, 0=middle, -1=inner
 n         $ Do you want to use fasteners (they are like rigid links)?
 n         $ Are the stringers to be "smeared out"?
 y         $ Are the rings to be "smeared out"?
   5       $ Number of nodes over height of stiffener webs, NODWEB
   5       $ Number of nodes over width of stringer flange, NDFLGS
   5       $ Number of nodes over width of ring flange, NDFLGR
 n         $ Do you want stringer(s) with a high nodal point density?
 n         $ Do you want ring(s) with a high nodal point density?
 n         $ Is there plasticity in this STAGS model?
 n         $ Do you want to use the "least-squares" model for torque?
 n         $ Is stiffener sidesway permitted at the panel edges?
 n         $ Do you want symmetry conditions along the straight edges?
   0       $ Edges normal to screen (0) in-plane deformable; (1) rigid
```

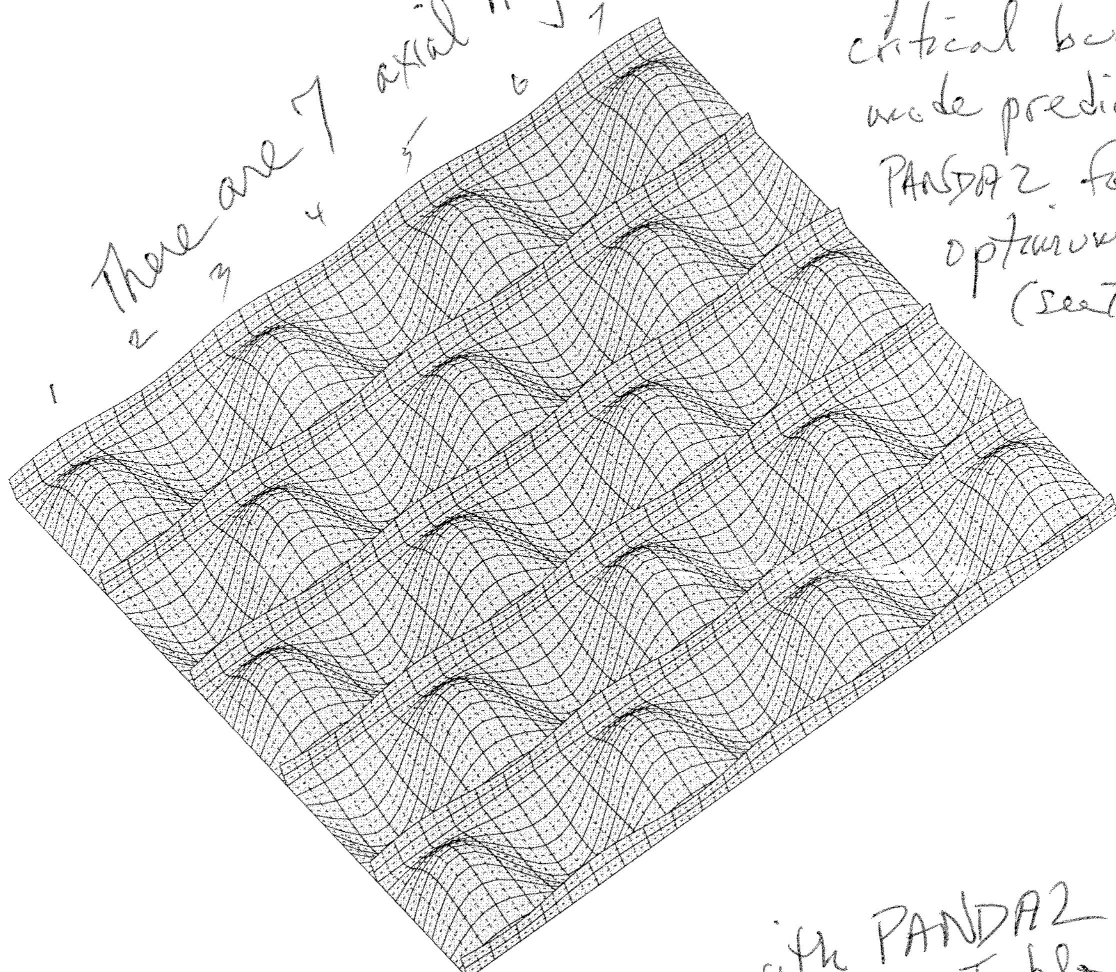
note

input for STAGSUNIT

output from STAGS processor, STAPL

riks.linbuck.realstiff.stay.pdf

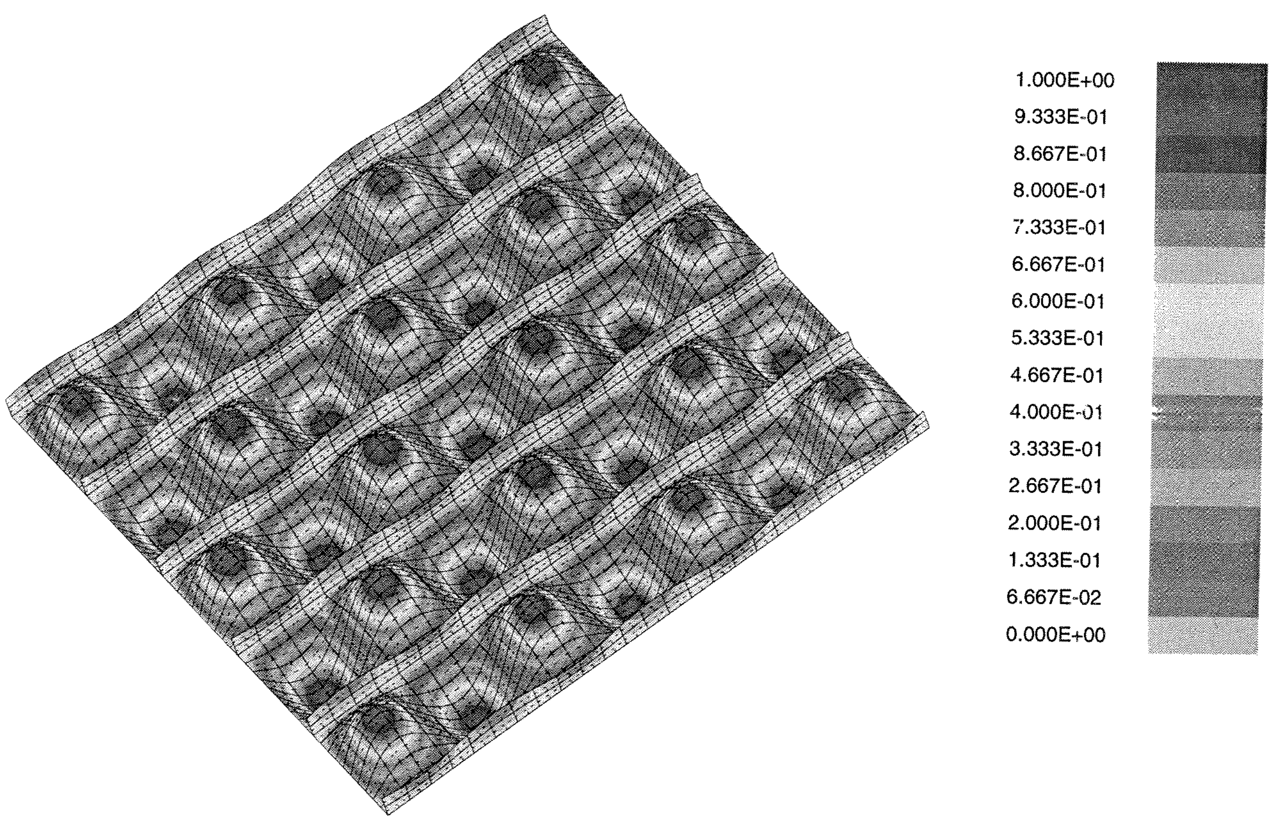
There are 7 axial half-waves in the critical buckling mode. This agrees with the critical buckling mode predicted by PANDA2 for the optimum designs. (See Table 1.35)



compare with PANDA2 prediction listed in Table 1.35: 0.26633 with 7 axial halfwaves.

Fig. 1.43

riks.linbuck.realstiff.5bay.wfringe.pdf



solution scale = 0.4334E+01
mode 1, pcr = 0.25038E+00
step 0 eigenvector veclngthcontours
linear buckling of perfect shell,fringe plot of modal displacement
Minimum value = 0.00000E+00, Maximum value = 1.00000E+00

Θ x -35.84
Θ y -13.14
Θ z 35.63

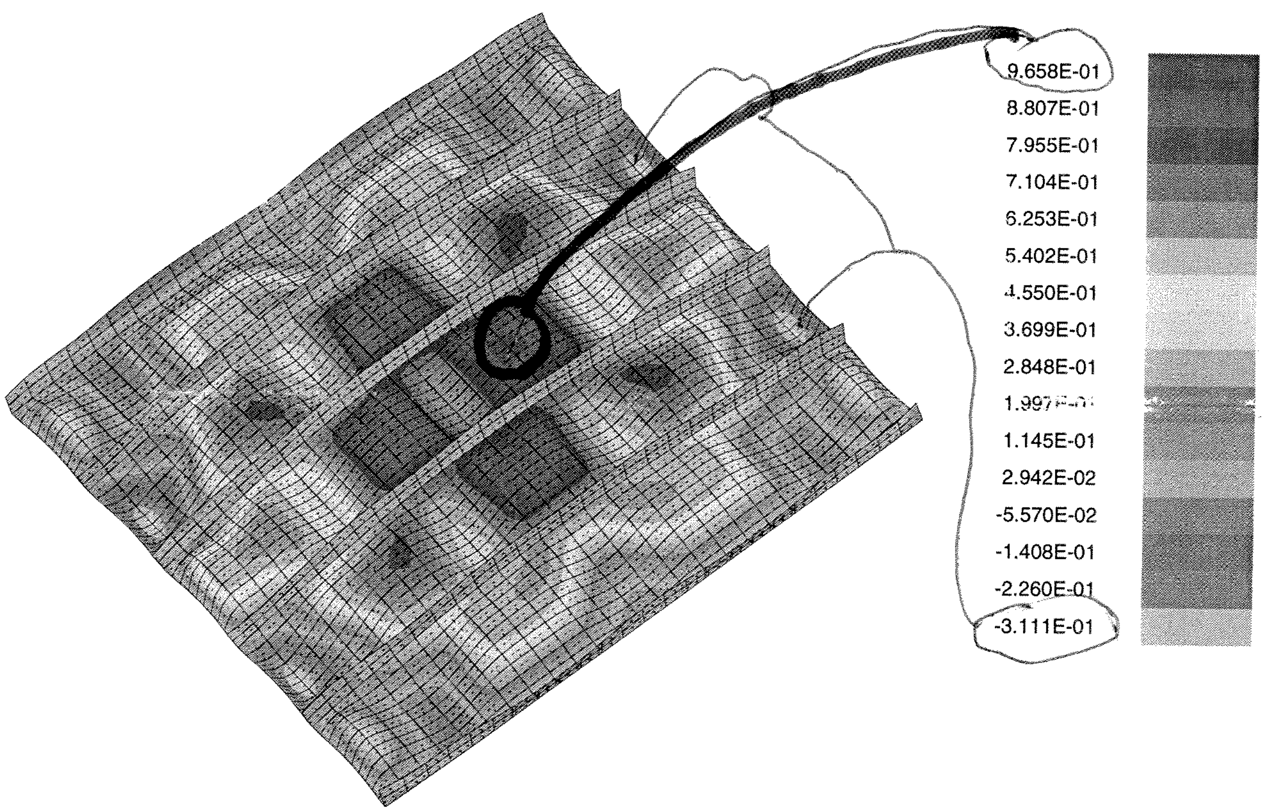
y z x

1.369E+01

Fig. 1.44

riks.postbuck.realstiff.5bay.step38.pdf

Note: PANDA2 does not predict the overall axial bowing evident in this figure.



solution scale = 0.4264E+01
PA= 9.68825E-01 PB= 0.00000E+00 PX= 0.00000E+00
step 38 displacement w contours
nonlinear w same view as linear buckling mode
Minimum value = -3.11076E-01, Maximum value = 9.65784E-01

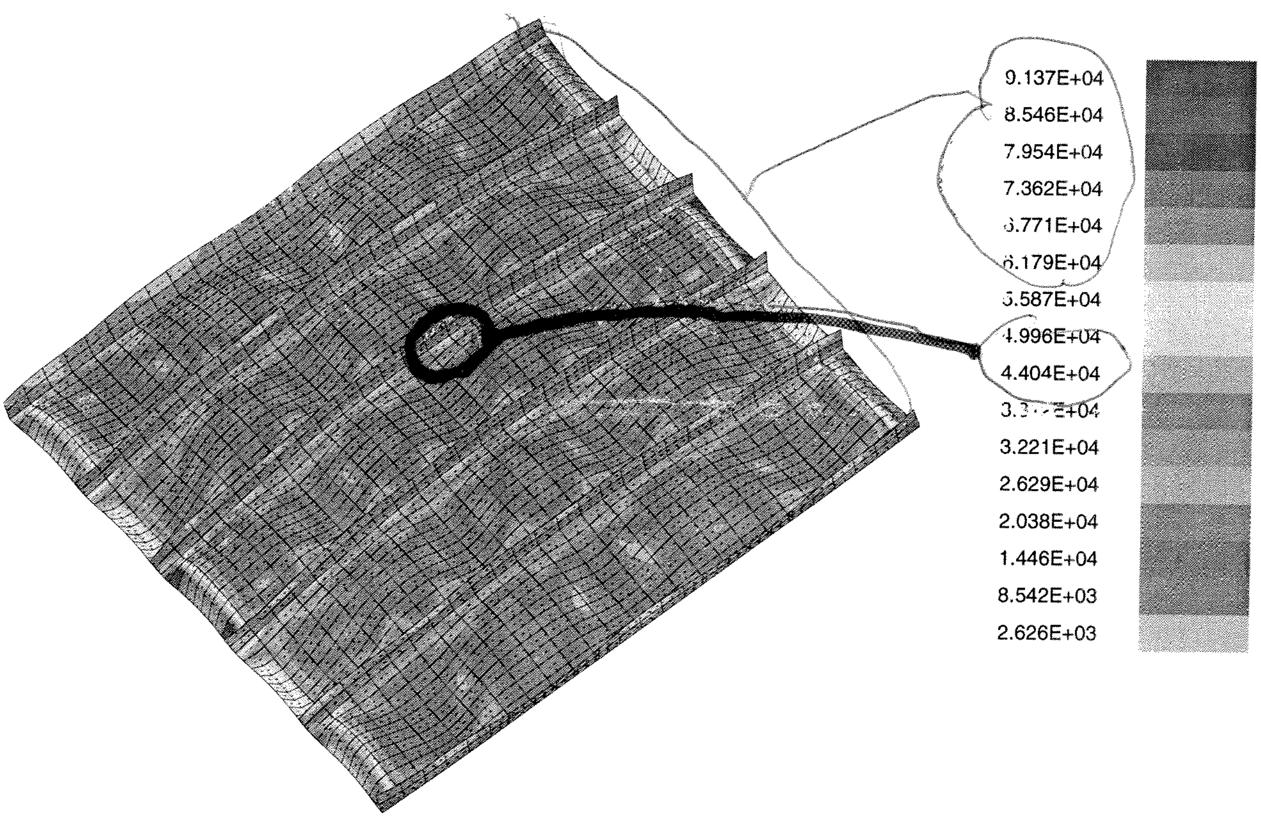
Θ x -35.84
Θ y -13.14
Θ z 35.63

y z x

1.369E+01

Fig. 1.45

riks.postbuck.realstiff.5bay.step38.seffinnerfiber.pdf



solution scale = 0.4264E+01
PA= 9.68825E-01 PB= 0.00000E+00 PX= 0.00000E+00
step 38 fabrication system ,seff, layer 1, inner fiber
nonlinear effective stress - inner fiber same view a linear buckling mode
Minimum value = 2.62592E+03, Maximum value = 9.13732E+04

Θ x -35.84
Θ y -13.14
Θ z 35.63

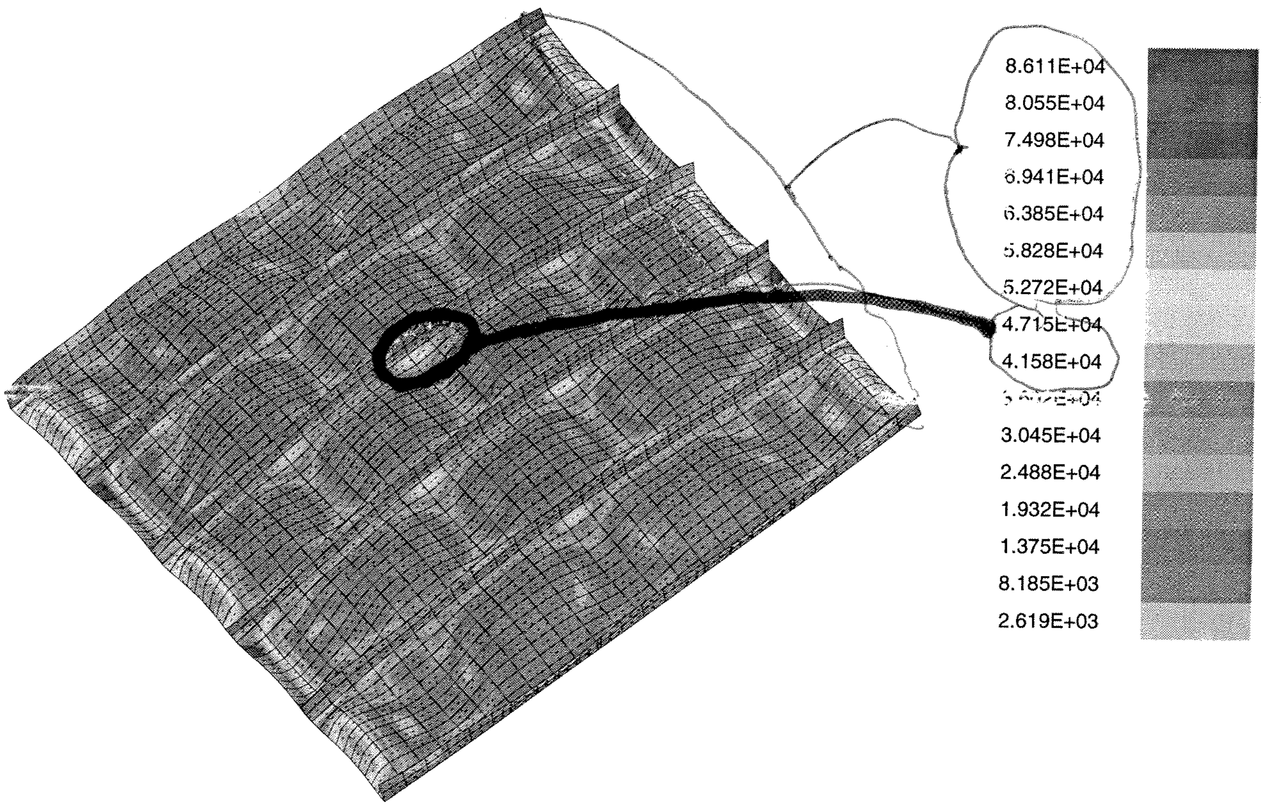
y z x

1.369E+01

135

Fig. 146

riks.postbuck.realstiff.5bay.step38.seffouterfiber.pdF



solution scale = 0.4264E+01
PA= 9.68825E-01 PB= 0.00000E+00 PX= 0.00000E+00
step 38 fabrication system ,seff, layer 1, outer fiber
nonlinear effective stress - ~~inner~~ outer fiber same view a linear buckling mode
Minimum value = 2.61913E+03, Maximum value = 8.61127E+04

Θ x -35.84
Θ y -13.14
Θ z 35.63

y z x

1.369E+01

136

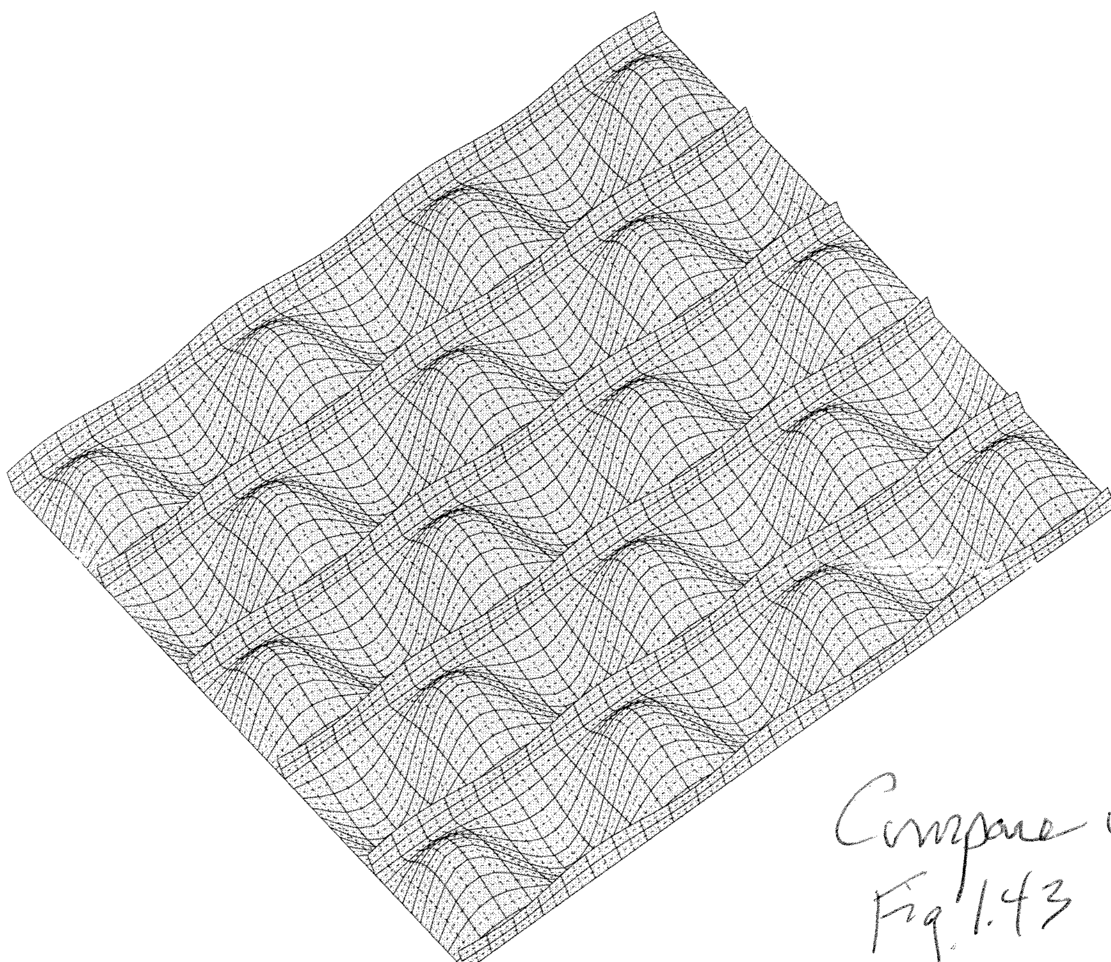
Fig. 1.47

riks.STG = riks.linear.rigidedges.stg Table 6.47

```
      n         $ Do you want a tutorial session and tutorial output?
         1      $ Choose type of STAGS analysis (1,3,4,5,6),INDIC
         0      $ Restart from ISTARTth load step (0=1st nonlinear soln), ISTART
  0.2600000     $ Local buckling load factor from PANDA2, EIGLOC
      y         $ Are the dimensions in this case in inches?
         0      $ Nonlinear (0) or linear (1) kinematic relations?, ILIN
         0      $ Type 1 for closed (360-deg) cyl. shell, 0 otherwise, ITOTAL
        50      $ X-direction length of the STAGS model of the panel: XSTAGS
        50      $ Panel length in the plane of the screen, L2
      y         $ Is the nodal point spacing uniform along the stringer axis?
        51      $ Number of nodes in the X-direction: NODEX
   -1000.       $ Resultant (e.g. lb/in) normal to the plane of screen, Nx
         0      $ Resultant (e.g. lb/in) in the plane of the screen,    Ny
         0      $ In-plane shear in load set A,                       Nxy
         0      $ Normal pressure in STAGS model in Load Set A, p
         0      $ Resultant (e.g. lb/in) normal to the plane of screen, Nx0
         0      $ Resultant (e.g. lb/in) in the plane of the screen,    Ny0
         0      $ Normal pressure in STAGS model in Load Set B, p0
         1      $ Starting load factor for Load System A, STLD(1)
         0      $ Load factor increment for Load System A, STEP(1)
         1      $ Maximum load factor for Load System A, FACM(1)
         0      $ Starting load factor for Load System B, STLD(2)
         0      $ Load factor increment for Load System B, STEP(2)
         0      $ Maximum load factor for Load System B, FACM(2)
         1      $ How many eigenvalues do you want? NEIGS
       480      $ Choose element type (410 or 411 or 480) for panel skin
      n         $ Have you obtained buckling modes from STAGS for this case?
         6      $ Number of stringers in STAGS model of the flat panel
         0      $ Number of rings in the STAGS model of the panel
      n         $ Are there rings at the ends of the panel?
        10      $ Number of finite elements between adjacent stringers
        25      $ Number of finite elements between adjacent rings
         3      $ Stringer model: 1 or 2 or 3 or 4 or 5(Type H(elp))
         3      $ Ring model: 1 or 2 or 3 or 4 or 5 (Type H(elp))
         0      $ Reference surface of cyl: 1=outer, 0=middle, -1=inner
      n         $ Do you want to use fasteners (they are like rigid links)?
      n         $ Are the stringers to be "smeared out"?
      y         $ Are the rings to be "smeared out"?
         5      $ Number of nodes over height of stiffener webs, NODWEB
         5      $ Number of nodes over width of stringer flange, NDFLGS
         5      $ Number of nodes over width of ring flange, NDFLGR
      n         $ Do you want stringer(s) with a high nodal point density?
      n         $ Do you want ring(s) with a high nodal point density?
      n         $ Is there plasticity in this STAGS model?
      n         $ Do you want to use the "least-squares" model for torque?
      n         $ Is stiffener sidesway permitted at the panel edges?
      n         $ Do you want symmetry conditions along the straight edges?
         1      $ Edges normal to screen (0) in-plane deformable; (1) rigid
```

note

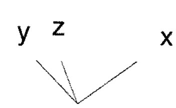
riks.linbuck.realstiff.5bay.rigidedges.pdf



Compare with Fig. 1.43

solution scale = 0.4334E+01
mode 1, pcr = 0.25038E+00
step 0 eigenvector deformed geometry
linear buckling of perfect shell

Θ x -35.84
Θ y -13.14
Θ z 35.63



1.140E+01

Fig. 1.48

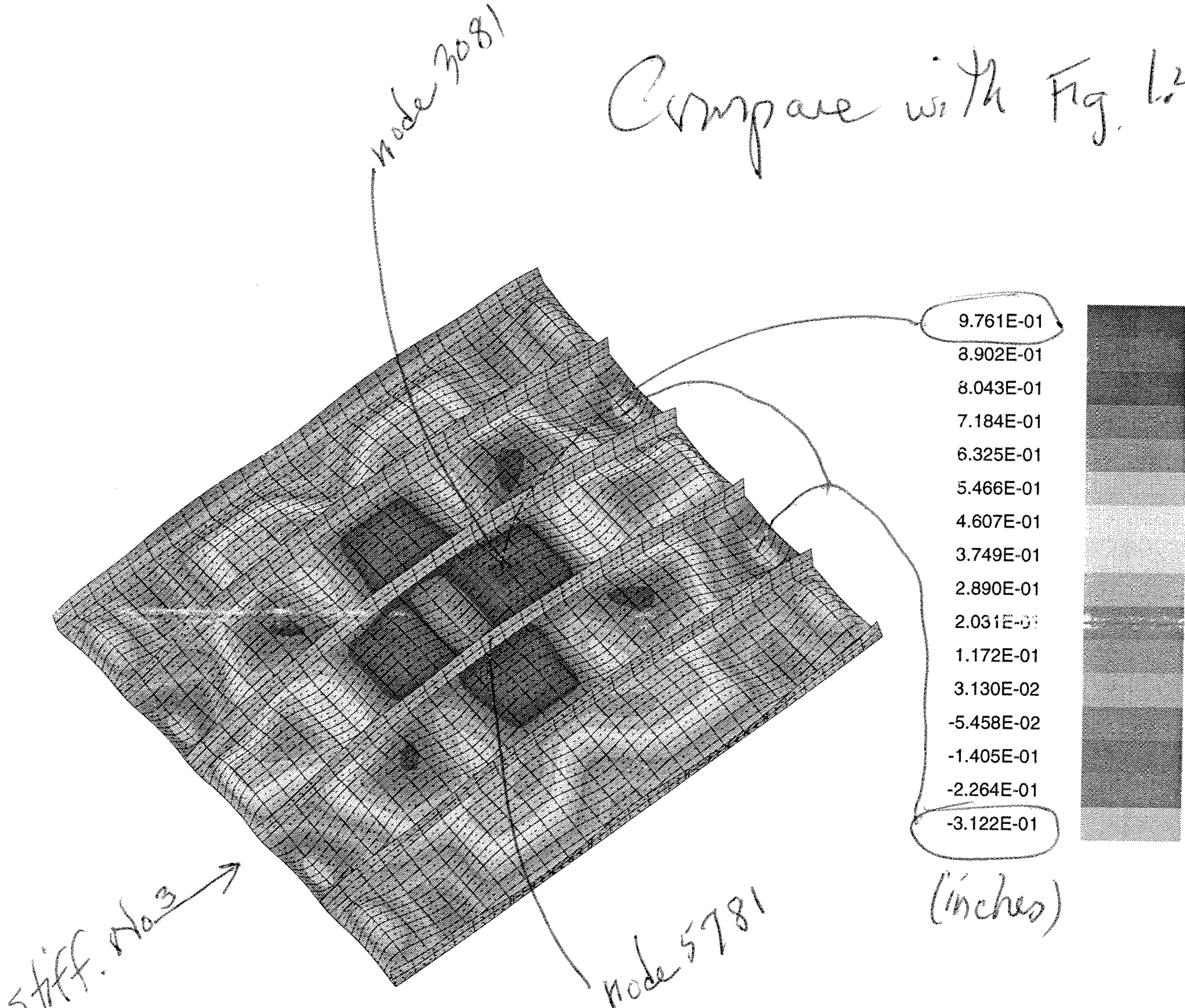
riks.STG = riks.nonlinear.rigidedges.stg Table 1.48

```
   n         $ Do you want a tutorial session and tutorial output?
    3        $ Choose type of STAGS analysis (1,3,4,5,6),INDIC
    0        $ Restart from ISTARTth load step (0=1st nonlinear soln), ISTART
0.2600000    $ Local buckling load factor from PANDA2, EIGLOC
   y         $ Are the dimensions in this case in inches?
    0        $ Nonlinear (0) or linear (1) kinematic relations?, ILIN
    0        $ Type 1 for closed (360-deg) cyl. shell, 0 otherwise, ITOTAL
   50        $ X-direction length of the STAGS model of the panel: XSTAGS
   50        $ Panel length in the plane of the screen, L2
   y         $ Is the nodal point spacing uniform along the stringer axis?
   51        $ Number of nodes in the X-direction: NODEX
-1000.000    $ Resultant (e.g. lb/in) normal to the plane of screen, Nx
    0        $ Resultant (e.g. lb/in) in the plane of the screen,    Ny
    0        $ In-plane shear in load set A,                        Nxy
    0        $ Normal pressure in STAGS model in Load Set A, p
    0        $ Resultant (e.g. lb/in) normal to the plane of screen, Nx0
    0        $ Resultant (e.g. lb/in) in the plane of the screen,    Ny0
    0        $ Normal pressure in STAGS model in Load Set B, p0
0.5000000E-01 $ Starting load factor for Load System A, STLD(1)
0.5000000E-01 $ Load factor increment for Load System A, STEP(1)
 1.000000    $ Maximum load factor for Load System A, FACM(1)
    0        $ Starting load factor for Load System B, STLD(2)
    0        $ Load factor increment for Load System B, STEP(2)
    0        $ Maximum load factor for Load System B, FACM(2)
    1        $ How many eigenvalues do you want? NEIGS
  480        $ Choose element type (410 or 411 or 480) for panel skin
   y         $ Have you obtained buckling modes from STAGS for this case?
   y         $ Do you want to provide initial imperfection(s)?
0.1000000E-01 $ Amplitude of initial buckling modal imperfection, WIMPL( 1)
    1        $ Run number for which this buckling mode was computed, IRUN( 1)
    0        $ Load step number at which this buckling mode was computed, ISTEP( 1)
    1        $ Mode number at the load step ISTEP of the run IRUN: IMODE( 1)
   n         $ Do you want to provide another imperfection?
    6        $ Number of stringers in STAGS model of the flat panel
    0        $ Number of rings in the STAGS model of the panel
   n         $ Are there rings at the ends of the panel?
   10        $ Number of finite elements between adjacent stringers
   25        $ Number of finite elements between adjacent rings
    3        $ Stringer model: 1 or 2 or 3 or 4 or 5(Type H(elp))
    3        $ Ring model: 1 or 2 or 3 or 4 or 5 (Type H(elp))
    0        $ Reference surface of cyl: 1=outer, 0=middle, -1=inner
   n         $ Do you want to use fasteners (they are like rigid links)?
   n         $ Are the stringers to be "smeared out"?
   y         $ Are the rings to be "smeared out"?
    5        $ Number of nodes over height of stiffener webs, NODWEB
    5        $ Number of nodes over width of stringer flange, NDFLGS
    5        $ Number of nodes over width of ring flange, NDFLGR
   n         $ Do you want stringer(s) with a high nodal point density?
   n         $ Do you want ring(s) with a high nodal point density?
   n         $ Is there plasticity in this STAGS model?
   n         $ Do you want to use the "least-squares" model for torque?
   n         $ Is stiffener sidesway permitted at the panel edges?
   n         $ Do you want symmetry conditions along the straight edges?
    1        $ Edges normal to screen (0) in-plane deformable; (1) rigid
```

note

riks.postbuck.realstiff.5bay.step26.rigidedges.pdf

Compare with Fig. 1.45



solution scale = 0.4219E+01
PA= 9.71414E-01 PB= 0.00000E+00 PX= 0.00000E+00
step 26 displacement w contours
nonlinear w same view as linear buckling mode
Minimum value = -3.12245E-01, Maximum value = 9.76060E-01

Θ x -35.84
Θ y -13.14
Θ z 35.63

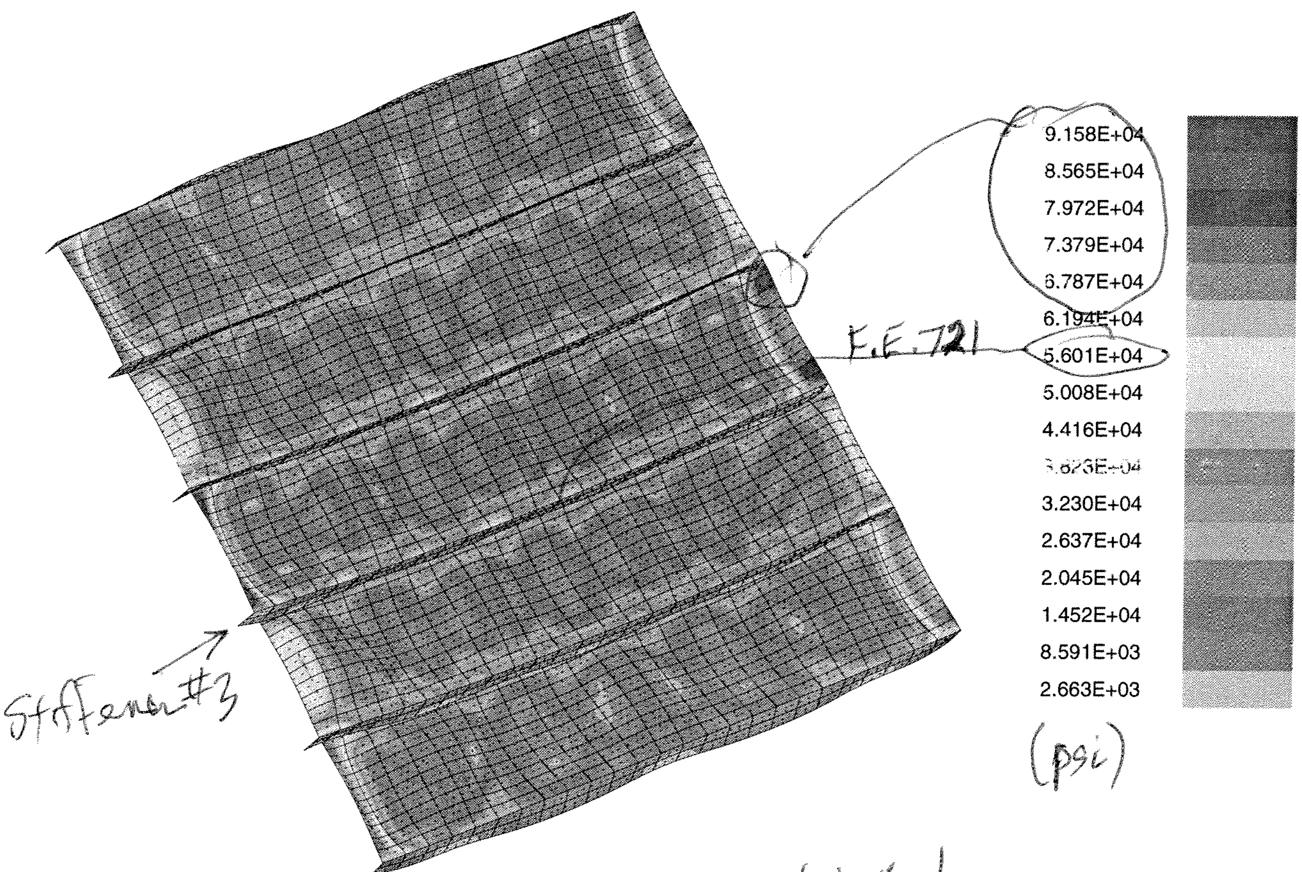
y z x

1.369E+01

Fig. 1.49(a)

riks.postbuck.realstiff.5bay.step26.rigidedges.seffinnerfiber.pdf

Compare with Fig. 1.46



seff = "effective" stress

solution scale = 0.3848E+01
PA= 9.70000E-01 PB= 0.00000E+00 PX= 0.00000E+00
step 26 fabrication system ,seff, layer 1, inner fiber
nonlinear effective stress - inner fiber
Minimum value = 2.66314E+03, Maximum value = 9.15753E+04

Θ x 24.00
Θ y -22.00
Θ z 30.00

1.283E+01

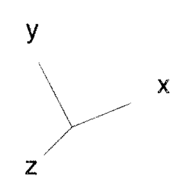
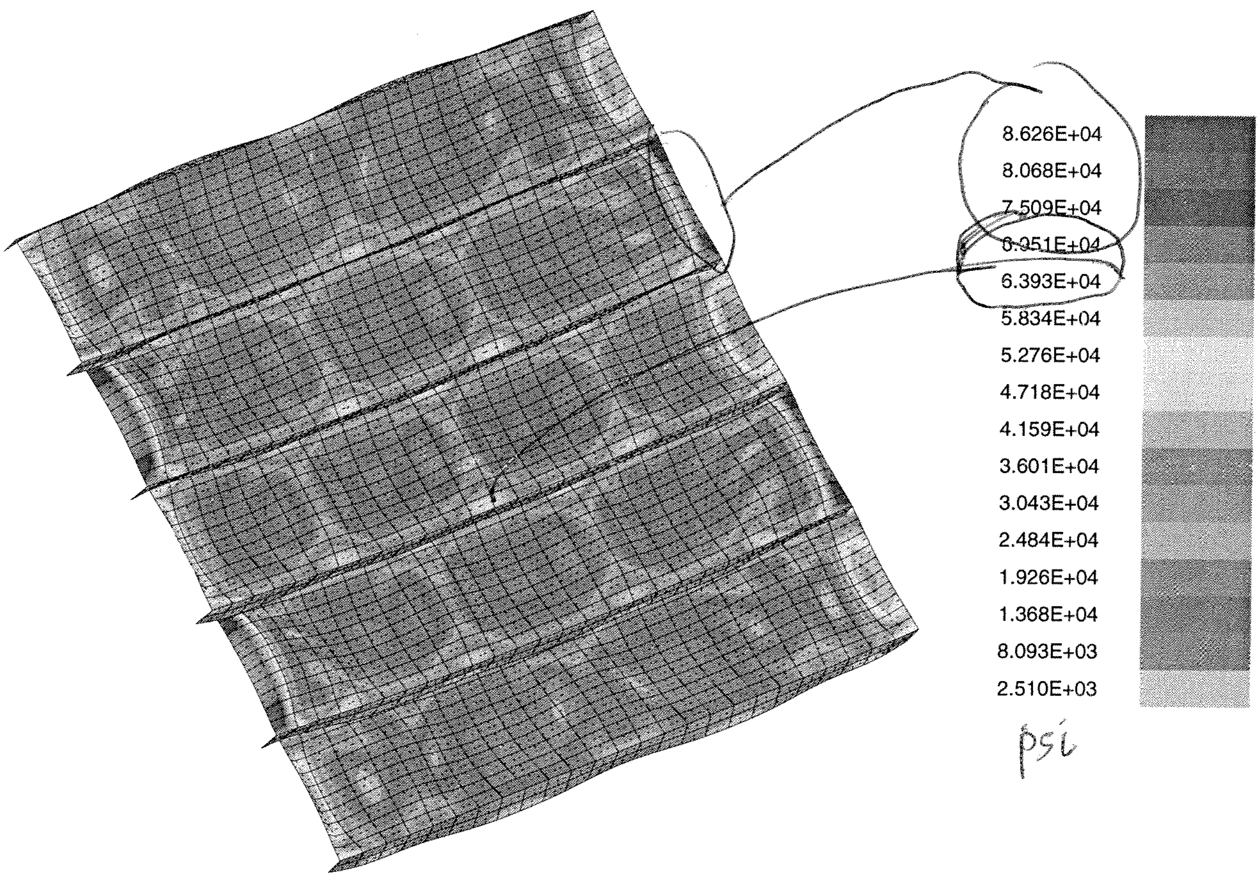


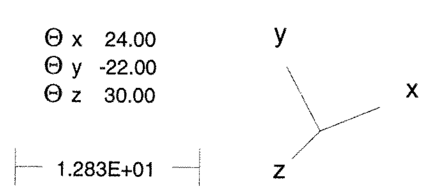
Fig. 1.49(b)

riks.postbuck.realstiff.5bay.step26.rigidedges.seffouterfiber.pdf

Compare with Fig. 1.47



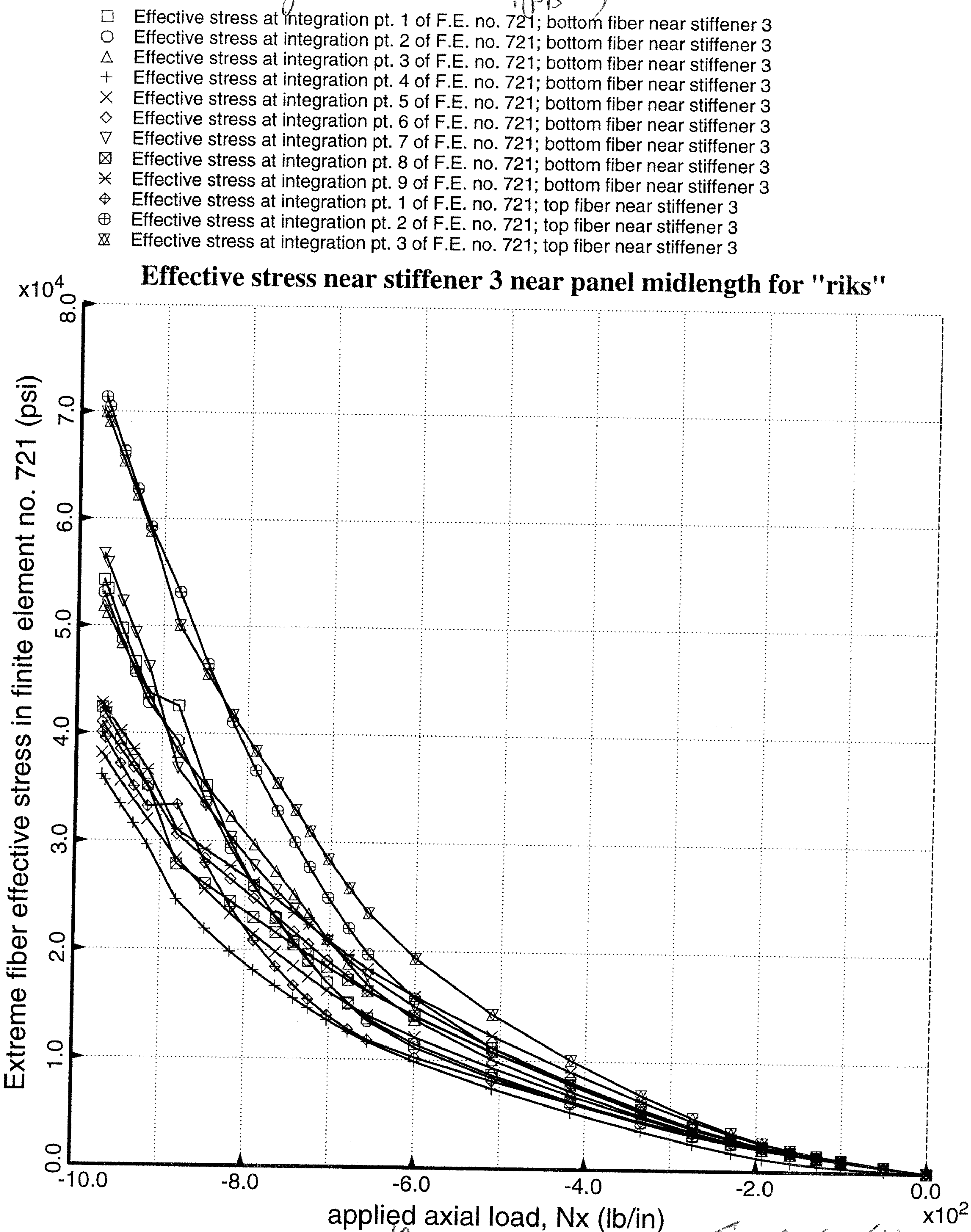
solution scale = 0.3848E+01
PA= 9.70000E-01 PB= 0.00000E+00 PX= 0.00000E+00
step 26 fabrication system ,seff, layer 1, outer fiber
nonlinear effective stress - ~~inner~~ fiber outer
Minimum value = 2.50977E+03, Maximum value = 8.62594E+04



142

Fig. 1.49(c)

riks.sigmabar.nearstiff.{input}.ips



143

Fig. 1.49(d)

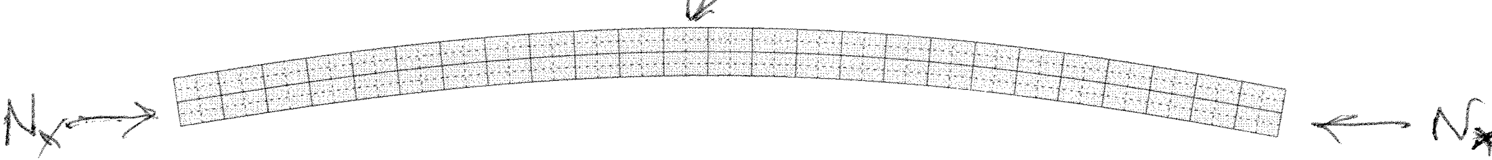
riks.postbuck.realstiff.5bay.sideview.stiffno3.pdf

output from STAPL
for Shell Unit #4 =
stiffener #3.

PANDA2 does <u>not</u> predict
this bowing deformation,
as explained in the text.

v vs. Nx plotted in the next Figure

node 5781



solution scale = 0.3288E+01
PA= 9.70000E-01 PB= 0.00000E+00 PX= 0.00000E+00
step 26 displacement deformed geometry
Nonlinear deformation, side view

Θ x -90.00
Θ y 0.00
Θ z -0.00

z
x
y

8.333E+00

Fig. 1.50

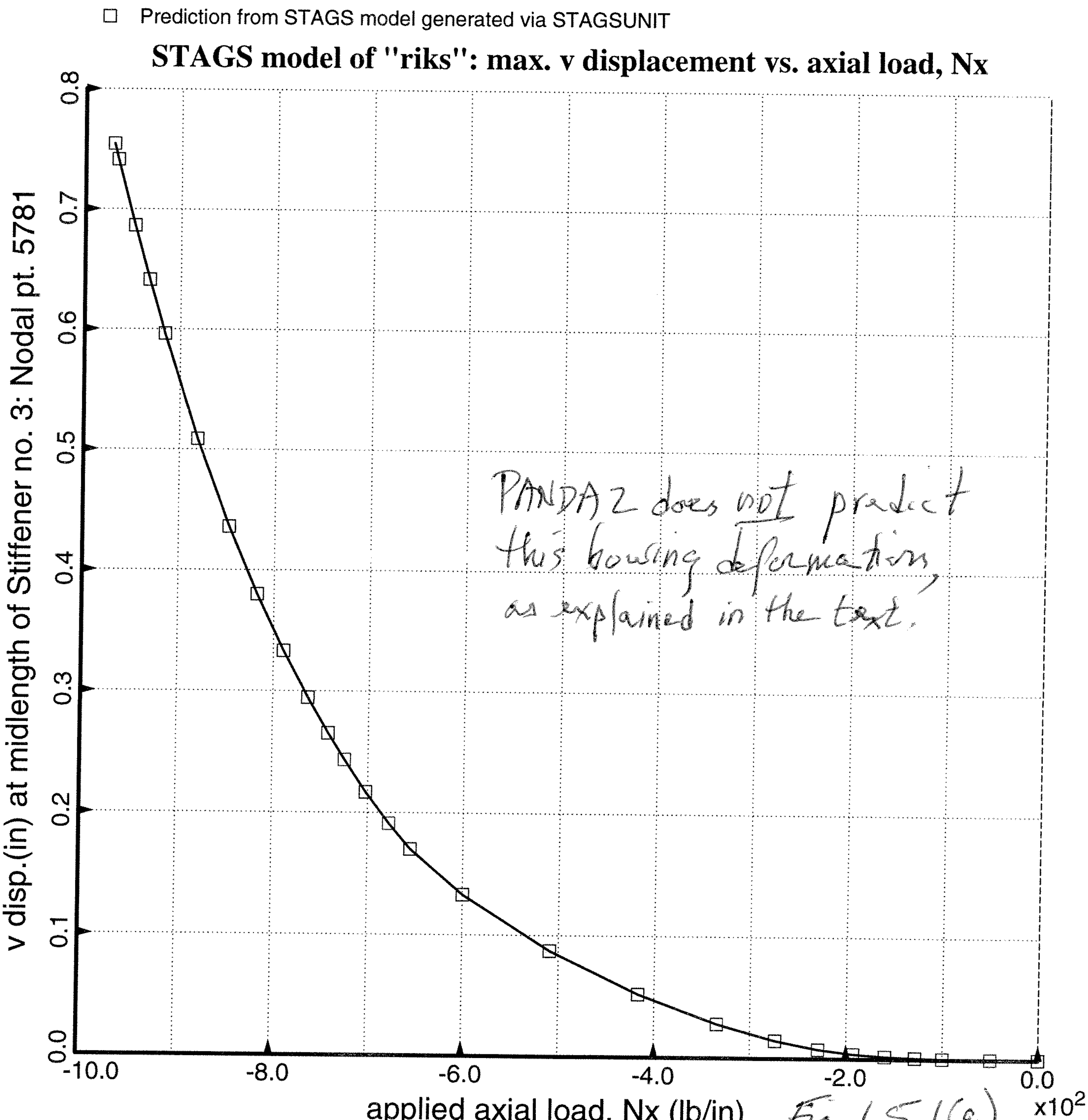
Table 1.49(a) riks.stiffno3.v.input

```
# riks.stiffno3.v.input (input to the application, /home/progs/bin/plotps.linux )
# This is a typical file from which a postscript file, riks.stiffno3.v.ps, is generated.
# The "x,y" input data come from STAGS results generated via the STAGS processor
# called "xytrans" after completion of a STAGS nonlinear equilibrium run.
# In order to generate a postscript file that can be sent to a printer,
# type the command:
#  /home/progs/bin/plotps.linux < riks.stiffno3.v.input > riks.stiffno3.v.ps
# Global directives, load-deflection curve for "riks" with axial loading
=title(STAGS model of "riks": max. v displacement vs. axial load, Nx)
=xlabel(applied axial load, Nx (lb/in))
=ylabel(v disp.(in) at midlength of Stiffener no. 3: Nodal pt. 5781)
# data set 1 Prediction from STAGS model generated via STAGSUNIT.
+legend(Prediction from STAGS model generated via STAGSUNIT)
+setmarker( 0)
  0.000000E+00    0.000000E+00
 -5.000000E+01    2.339285E-04
 -1.000000E+02    6.946952E-04
 -1.284573E+02    1.185467E-03
 -1.597499E+02    2.131595E-03
 -1.927910E+02    3.989119E-03
 -2.291033E+02    7.634806E-03
 -2.738815E+02    1.471948E-02
 -3.345164E+02    2.809446E-02
 -4.169353E+02    5.212735E-02
 -5.092850E+02    8.738476E-02
 -5.998217E+02    1.328658E-01
 -6.549292E+02    1.700641E-01
 -6.775533E+02    1.910600E-01
 -7.023360E+02    2.168599E-01
 -7.247554E+02    2.433638E-01
 -7.419851E+02    2.653049E-01
 -7.635771E+02    2.945822E-01
 -7.895001E+02    3.331663E-01
 -8.174851E+02    3.798206E-01
 -8.472409E+02    4.358896E-01
 -8.809984E+02    5.086458E-01
 -9.158069E+02    5.963151E-01
 -9.322494E+02    6.411988E-01
 -9.480286E+02    6.863829E-01
 -9.659609E+02    7.412923E-01
 -9.700000E+02    7.543517E-01
```

maximum local buckling lobe amplitude is 0.9761 − 0.7543 = 0.2218 inch. at $N_x = -970$ lb/in. Compare with Fig. 1.53

See Fig. 1.49

riks.stiffno3.v.{input ps}



146

Fig 1.51(a)

Table 1.49(b) riks.stiffno3andbuckle.input

```
# riks.stiffno3andbuckle.input (input to the application, /home/progs/bin/plotps.linux )
# This is a typical file from which a postscript file, riks.stiffno3andbuckle.ps, is generated.
# The "x,y" input data come from STAGS results generated via the STAGS processor
# called "xytrans" after completion of a STAGS nonlinear equilibrium run.
# In order to generate a postscript file that can be sent to a printer,
# type the command:
#  /home/progs/bin/plotps.linux < riks.stiffno3andbuckle.input > riks.stiffno3andbuckle.ps
# Global directives, load-deflection curve for "riks" with axial loading
=title(STAGS "riks": Compare average bowing & max.w vs. axial load, Nx)
=xlabel(applied axial load, Nx (lb/in))
=ylabel(bowing at midlength (Node 5781) and max. normal disp. w (in)(Node 3081))
# data set 1 Prediction from STAGS model generated via STAGSUNIT.
+legend(Bowing at panel midlength of Stiffener No. 3)
+setmarker( 0)
   0.000000E+00     0.000000E+00
  -5.000000E+01     2.339285E-04
  -1.000000E+02     6.946952E-04
  -1.284573E+02     1.185467E-03
  -1.597499E+02     2.131595E-03
  -1.927910E+02     3.989119E-03
  -2.291033E+02     7.634806E-03
  -2.738815E+02     1.471948E-02
  -3.345164E+02     2.809446E-02
  -4.169353E+02     5.212735E-02
  -5.092850E+02     8.738476E-02
  -5.998217E+02     1.328658E-01
  -6.549292E+02     1.700641E-01
  -6.775533E+02     1.910600E-01
  -7.023360E+02     2.168599E-01
  -7.247554E+02     2.433638E-01
  -7.419851E+02     2.653049E-01
  -7.635771E+02     2.945822E-01
  -7.895001E+02     3.331663E-01
  -8.174851E+02     3.798206E-01
  -8.472409E+02     4.358896E-01
  -8.809984E+02     5.086458E-01
  -9.158069E+02     5.963151E-01
  -9.322494E+02     6.411988E-01
  -9.480286E+02     6.863829E-01
  -9.659609E+02     7.412923E-01
  -9.700000E+02     7.543517E-01

# data set 2 Prediction from STAGS model generated via STAGSUNIT.
+legend(Maximum normal displacement w at outward buckling lobe)
+setmarker( 1)
   0.000000E+00     0.000000E+00
  -5.000000E+01     1.622746E-03
  -1.000000E+02     4.306890E-03
  -1.284573E+02     6.713517E-03
  -1.597499E+02     1.063850E-02
  -1.927910E+02     1.695922E-02
  -2.291033E+02     2.700202E-02
  -2.738815E+02     4.288540E-02
  -3.345164E+02     6.774538E-02
  -4.169353E+02     1.059752E-01
  -5.092850E+02     1.565847E-01
  -5.998217E+02     2.188193E-01
  -6.549292E+02     2.692950E-01
  -6.775533E+02     2.975111E-01
  -7.023360E+02     3.309633E-01
  -7.247554E+02     3.644846E-01
  -7.419851E+02     3.915611E-01
  -7.635771E+02     4.269995E-01
  -7.895001E+02     4.731238E-01
  -8.174851E+02     5.285127E-01
  -8.472409E+02     5.947390E-01
  -8.809984E+02     6.796541E-01
  -9.158069E+02     7.575121E-01
  -9.322494E+02     8.047718E-01
  -9.480286E+02     8.531822E-01
  -9.659609E+02     9.115831E-01
  -9.700000E+02     9.253268E-01
```

riks.stiffno3andbuckle.{input, ps}

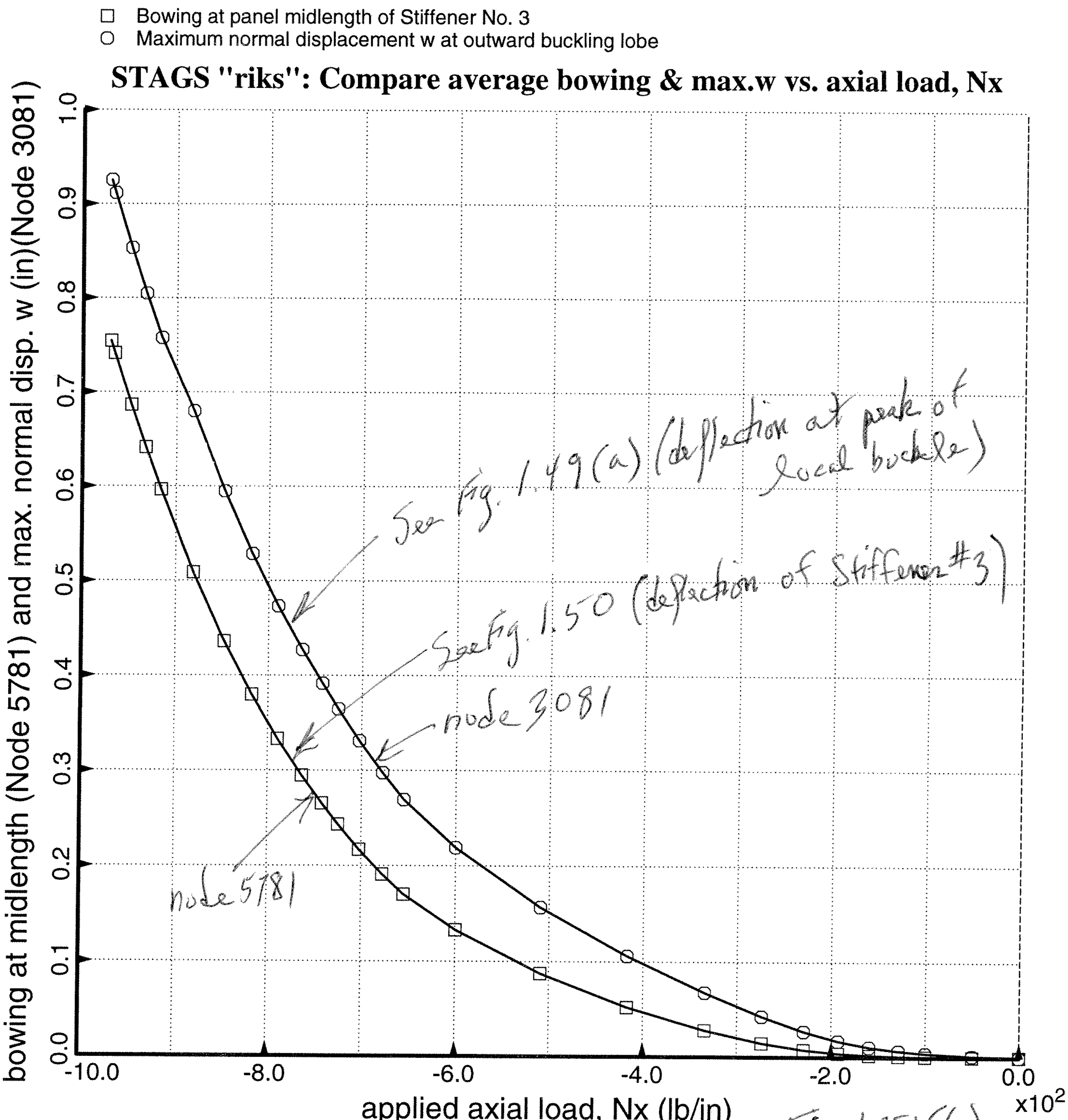


Fig. 1.51(b)

Table 1.50(a) riks.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?
       3       $ Number of parameter to change (1, 2, 3, . .)
 2.113900      $ New value of the parameter
    y          $ Want to change any other parameters in this set?
       4       $ Number of parameter to change (1, 2, 3, . .)
0.6420300E-01  $ New value of the parameter
    y          $ Want to change any other parameters in this set?
       5       $ Number of parameter to change (1, 2, 3, . .)
0.1814700      $ 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?
```

stiffener height

skin thickness

stiffener thickness

This is a good way to save an optimum design.

Table 1.50(b) riks.opt3 (input for MAINSETUP=riks.OPT)

```
         n      $ Do you want a tutorial session and tutorial output?
   -50.000      $ Resultant (e.g. lb/in) normal to the plane of screen, Nx( 1)
         0      $ Resultant (e.g. lb/in) in the plane of the screen,    Ny( 1)
         0      $ In-plane shear in load set A,                       Nxy( 1)
         n      $ Does the axial load vary in the L2 direction?
  0.000000      $ Applied axial moment resultant (e.g. in-lb/in), Mx( 1)
  0.000000      $ Applied hoop moment resultant (e.g. in-lb/in), My( 1)
         Y      $ Want to include effect of transverse shear deformation?
         0      $ IQUICK = quick analysis indicator (0 or 1)
         Y      $ Do you want to vary M for minimum local buckling load?
         N      $ Do you want to choose a starting M for local buckling?
         Y      $ Do you want to perform a "low-axial-wavenumber" search?
 1.0000000      $ Factor of safety for general instability, FSGEN( 1)
 0.2000000      $ Minimum load factor for local buckling (Type H for HELP), FSLOC( 1)
  1.000000      $ Minimum load factor for stiffener buckling (Type H), FSBSTR( 1)
  1.000000      $ Factor of safety for stress, FSSTR( 1)
         Y      $ Do you want "flat skin" discretized module for local buckling?
         N      $ Do you want wide-column buckling to constrain the design?
  0.000000      $ Resultant (e.g. lb/in) normal to the plane of screen, Nx0( 1)
  0.000000      $ Resultant (e.g. lb/in) in the plane of the screen,    Ny0( 1)
         0      $ Axial load applied along the (0=neutral plane), (1=panel skin)
  0.000000      $ Uniform applied pressure [positive upward. See H(elp)], p( 1)
  0.000000      $ Out-of-roundness, Wimpg1=(Max.diameter-Min.diam)/4, Wimpg1( 1)
  0.000000      $ Initial buckling modal general imperfection amplitude, Wimpg2( 1)
  0.010000      $ Initial local imperfection amplitude (must be positive), Wloc( 1)
         Y      $ Do you want PANDA2 to change imperfection amplitudes (see H(elp))?( 1)
        50      $ Axial halfwavelength of typical general buckling mode, AXLWAV( 1)
         Y      $ Do you want PANDA2 to find the general imperfection shape?( 1)
  1.000000      $ Maximum allowable average axial strain (type H for HELP)( 1)
         N      $ Is there any thermal "loading" in this load set (Y/N)?
         Y      $ Do you want a "complete" analysis (type H for "Help")?
         N      $ Want to provide another load set ?
         N      $ Do you want to impose minimum TOTAL thickness of any segment?
         N      $ Do you want to impose maximum TOTAL thickness of any segment?
         N      $ Use reduced effective stiffness in panel skin (H(elp), Y or N)?
         0      $ NPRINT= output index (-1=min. 0=good, 1=ok, 2=more, 3=too much)
         1      $ Index for type of shell theory (0 or 1 or 2), ISAND
         Y      $ Does the postbuckling axial wavelength of local buckles change?
         Y      $ Want to suppress general buckling mode with many axial waves?
         N      $ Do you want to double-check PANDA-type eigenvalues [type (H)elp]?
         0      $ Choose (0=transverse inextensional; 1=transverse extensional)
         1      $ Choose ICONSV = -1 or 0 or 1 or H(elp), ICONSV
         3      $ Choose type of analysis (ITYPE = 1 or 2 or 3 or 4 or 5)
         Y      $ Do you want to prevent secondary buckling (mode jumping)?
         n      $ Do you want to use the "alternative" buckling solution?
         1      $ Choose one of the load sets:  ILOAD
         1      $ Choose one of the sub cases (1  or  2):  ICASE
 -50.00000      $ Increment in axial resultant Nx:  DNX
         0      $ Increment in hoop resultant Ny:  DNY
         0      $ Increment in shear resultant Nxy:  DNXY
         0      $ Increment in axial moment resultant Mx:  DMX
         0      $ Increment in circumferential moment resultant My:  DMY
         0      $ Increment in pressure, p:  DP
         0      $ Starting multiplier for temperature distribution, TMULT
         0      $ Multiplier increment for temperature distribution, DTMULT
        20      $ Maximum number of load steps, NSTEPS
```

test simulation of optimized panel with PANDA2