SSNS102 - Buckling of a cylindrical hull with stiffener

Summary:

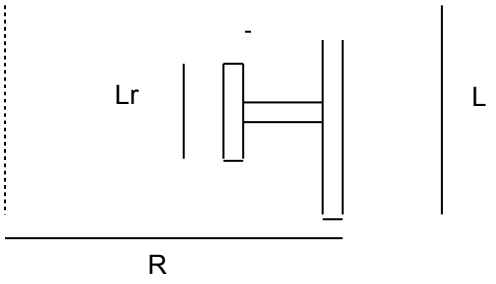
This test of nonlinear quasi-static mechanics makes it possible to validate the elements SHB8 and SHB20 into nonlinear geometrical, with or without taking into account of the following pressures and buckling of Euler. He shows the capacities of this element to deal with problems of thin hulls with stiffener.

1 Problem of reference

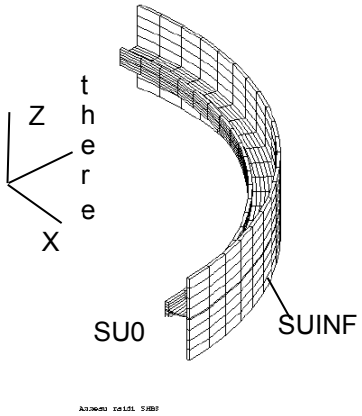
1.1 Geometry

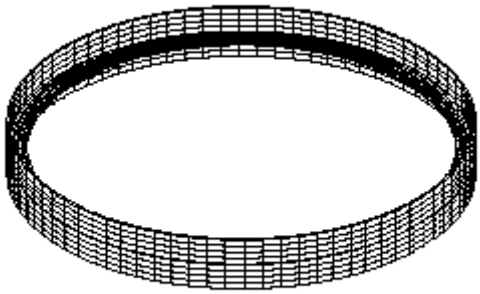
Cylindrical hull (which one will be able to represent a quarter), comprising a stiffener surfaces intern of it.

The section (axisymmetric) is following form:



SU90





Geometry: Ray $R=2.488\,m$
Height $L=600\,m$
Thickness $h=0.024\,m$
Heart $la=0.156\,m$, $h=0.01\,m$
Stiffener $lr=0.120\,m$, $h=0.024\,m$

1.2 Properties of material

Material: $E=2.10^{11}\,Pa$
$\nu=0.3$

1.3 Boundary conditions and loadings

Boundary conditions of symmetry: with $SU90$: DX = 0

$SU0$: DY = 0
on $SUINF$: DZ = 0

Loading: Uniform external pressure $P=1\,Pa$ regarded as nonfollowing pressure then following

2 Reference solution

2.1 Method of calculating

Digital solution [bib1]: values of the moment (thus of the external pressure) according to the radial displacement of the point $P2$ (with nonfollowing pressure).

2.2 Sizes and results of reference

The critical loads of Euler found by INCA [bib1] are:

Mode	Size	Unit	Reference: (INCA)
1	Pcr	(Pa)	1.27522
2	Pcr	(Pa)	2.70735
3	Pcr	(Pa)	2.81099
4	Pcr	(Pa)	2.83234
5	Pcr	(Pa)	3.11185
6	Pcr	(Pa)	3.25732
7	Pcr	(Pa)	3.61713
8	Pcr	(Pa)	3.99700
9	Pcr	(Pa)	4.07395
10	Pcr	(Pa)	4.10499

In great displacements, without following pressure, the solution found by INCA is:

Moment = pressure	Radial displacement point
1.000E-01	– 6.414E-04
2.000E-01	– 1.288E-03
3.001E-01	– 1.942E-03
4.000E-01	– 2.604E-03
4.999E-01	– 3.279E-03
5.996E-01	– 3.971E-03
6.987E-01	– 4.688E-03
7.964E-01	– 5.443E-03
8.909E-01	– 6.256E-03
9.768E-01	– 7.142E-03
1.056E+00	– 8.254E-03
1.103E+00	– 9.278E-03
1.130E+00	– 1.020E-02
1.148E+00	– 1.106E-02
1.160E+00	– 1.189E-02
1.169E+00	– 1.271E-02
1.175E+00	– 1.351E-02
1.181E+00	– 1.430E-02
1.185E+00	– 1.509E-02
1.188E+00	– 1.587E-02
1.191E+00	– 1.681E-02
1.194E+00	– 1.774E-02
1.196E+00	– 1.866E-02
1.197E+00	– 1.959E-02
1.199E+00	– 2.051E-02
1.200E+00	– 2.144E-02
1.201E+00	– 2.236E-02

1.201E+00	– 2.328E-02
1.202E+00	– 2.420E-02
1.202E+00	– 2.512E-02
1.203E+00	– 2.622E-02
1.203E+00	– 2.732E-02
1.203E+00	– 2.843E-02
1.204E+00	– 2.953E-02
1.204E+00	– 3.063E-02
1.204E+00	– 3.172E-02
1.204E+00	– 3.282E-02
1.203E+00	– 3.391E-02
1.203E+00	– 3.500E-02
1.203E+00	– 3.608E-02
1.203E+00	– 3.737E-02
1.203E+00	– 3.866E-02
1.202E+00	– 3.992E-02
1.202E+00	– 4.115E-02
1.202E+00	– 4.234E-02
1.202E+00	– 4.347E-02
1.201E+00	– 4.450E-02
1.201E+00	– 4.540E-02
1.201E+00	– 4.609E-02
1.202E+00	– 4.644E-02

2.3 Uncertainties on the solution

Without object

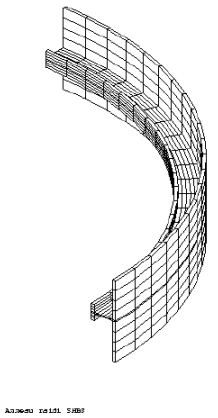
2.4 References

[1] " Elastoplastic Stability analysis oh shells using the physically stabilised finite element SHB8PS" A.Legay, A.Combescure, International Newspaper for Numerical Methods in Engineering, 20 1-6, 2000,

3 Modeling A

3.1 Characteristics of modeling

1/4 stiffened cylinder:



3.2 Characteristics of the grid

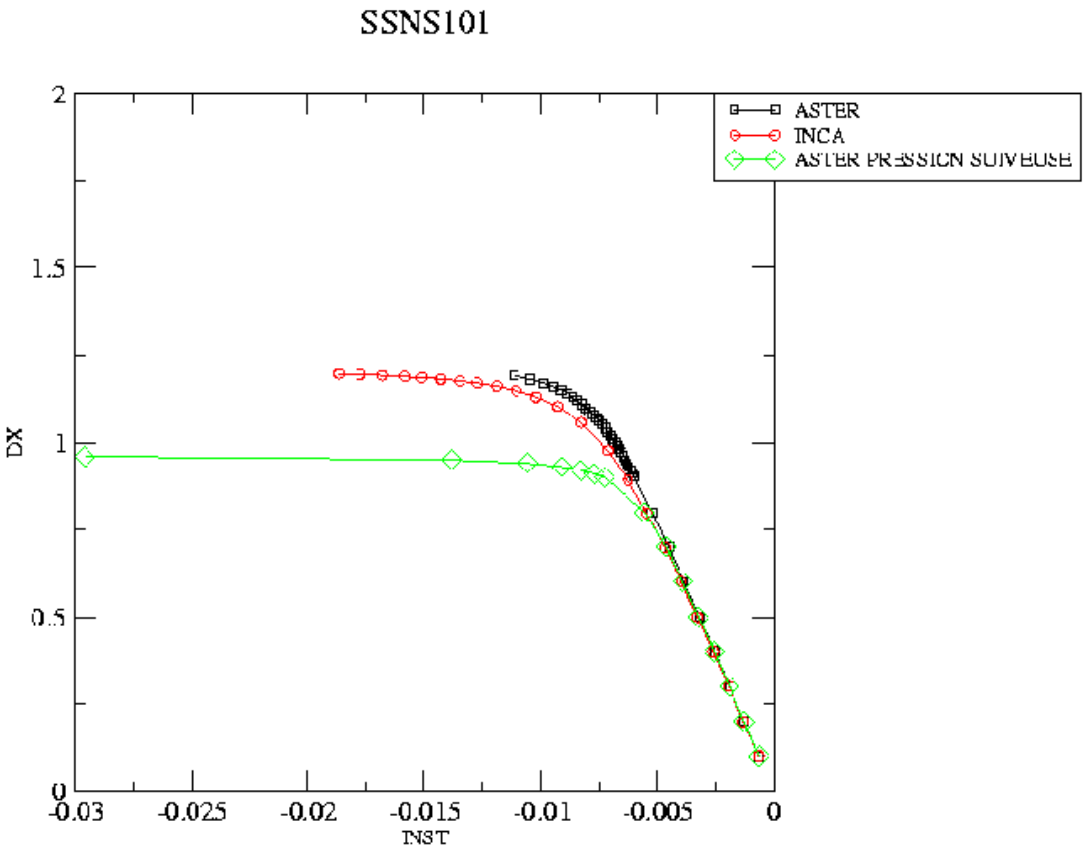
966 nodes, 440 SHB8,
180 QUAD4 (external skin)

3.3 Sizes tested and results

The 1 era critical load of Euler calculated in "linear elasticity (small displacements) is worth:

Mode	Size		Reference: (INCA)	*Aster*	%différence
1	Pcr	(Pa)	1.27522	1.24	– 2.8%

In great displacements, without and with following pressure, curved pressure-displacement calculated is the following one:



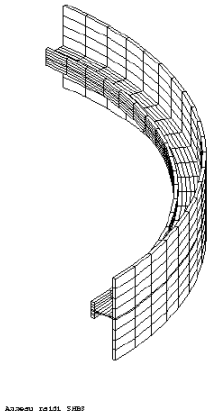
The reference solution (INCA calculation without following pressure) is compared with the solution *Aster* in the following table:

Moment	Dx reference	*Aster*	%différence
1.00000E – 01	– 6.4140000000000D-04	– 6.3006176337386D-04	– 1,768
2.00000E – 01	– 1.2880000000000D-03	– 1.2632416324434D-03	– 1,922
3.00100E – 01	– 1.9420000000000D-03	– 1.9010690490242D-03	– 2,108
4.00000E – 01	– 2.6040000000000D-03	– 2.5432700501389D-03	– 2,332
4.99900E – 01	– 3.2790000000000D-03	– 3.1933972632090D-03	– 2,611
5.99600E – 01	– 3.9710000000000D-03	– 3.8536429365519D-03	– 2,955
6.98700E – 01	– 4.6880000000000D-03	– 4.5271166527079D-03	– 3,432
7.96400E – 01	– 5.4430000000000D-03	– 5.2186387464667D-03	– 4,122
8.90900E – 01	– 6.2560000000000D-03	– 5.9353730232798D-03	– 5,125

4 Modeling B

4.1 Characteristics of modeling

1/4 stiffened cylinder:



4.2 Characteristics of the grid

3293 nodes, 440 SHB20,
180 QUAD8 (external skin)

4.3 Sizes tested and results

The 1 era critical load of Euler calculated in "linear elasticity (small displacements)" is worth:

Mode	Size		Reference: (INCA)	*Aster*	%différence
1	Pcr	(Pa)	1.27522	1.23	– 3.5%

In great displacements, without and with following pressure, curved pressure-displacement calculated is the following one:

The reference solution (INCA calculation without following pressure) is compared with the solution *Aster* in the following table:

Moment	Dx reference	*Aster*	%différence
1.00000E– 01	– 6.4140000000000D-04	– 6.3119635530626D-04	– 1,591
2.00000E – 01	– 1.2880000000000D-03	– 1.2655634673936D-03	– 1,742
3.00100E – 01	– 1.9420000000000D-03	– 1.9046566026826D-03	– 1,923
4.00000E – 01	– 2.6040000000000D-03	– 2.5482463080658D-03	– 2,141
4.99900E – 01	– 3.2790000000000D-03	– 3.1999661426587D-03	– 2,410
5.99600E – 01	– 3.9710000000000D-03	– 3.8621475556741D-03	– 2,741
6.98700E – 01	– 4.6880000000000D-03	– 4.5383923586560D-03	– 3,191
7.96400E – 01	– 5.4430000000000D-03	– 5.2340019182260D-03	– 3,840
8.90900E – 01	– 6.2560000000000D-03	– 5.9581981972785D-03	– 4,760

5 Summary of the results

Results got by *Code_Aster* with the elements SHB8 and SHB20 show their capacity to deal with problems of thin hulls with nongeometrical linearities.
The results with nonfollowing pressure are close to those of the reference. They are a little better with SHB20 that with SHB8, for the same number of meshs.
The results with following pressure, for which one does not have a reference solution, show all the same the good taking into account of this assumption in calculations.