SSNS102 - Buckling of a cylindrical shell with Summarized

stiffener:

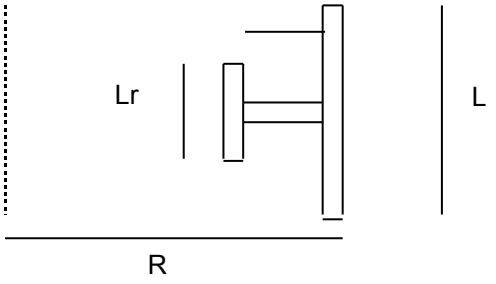
This test of nonlinear quasi-static mechanics makes it possible to validate elements SHB8 and SHB20 in nonlinear geometrical, with or without taking into account of the following pressures and buckling of Eulerian. It shows the capacities of this element to dealing with problems of thin shells with stiffener.

1 Problem of reference

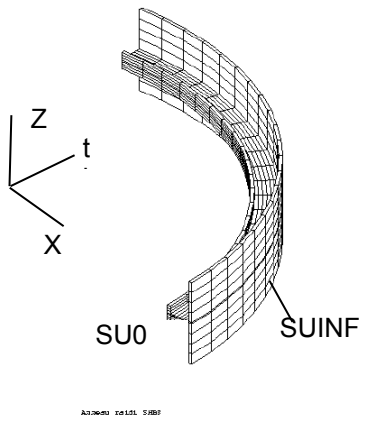
1.1 Geometry

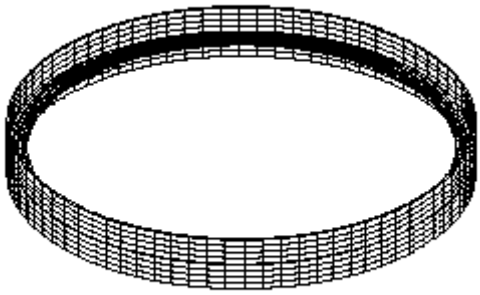
Cylindrical shell (which one will be able to represent a quarter), comprising a stiffener surfaces intern of it.

The section (axisymmetric) is following form:



SU90





Geometry: Radius $R=2.488\,m$
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 the 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 $P=1\,Pa$ considered as nonfollowing pressure then following

2 Reference solution

2.1 numerical

Method of calculating Solution [bib1]: values of time (thus of the external pressure) according to the radial displacement of the point $P2$ (with nonfollowing pressure).

2.2 Quantities and results of reference

the critical loads of Eulerian found by INCA [bib1] are:

Mode	Quantity	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 large displacements, without following pressure, the solution found by INCA is:

Time = pressure	Radial displacement not
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

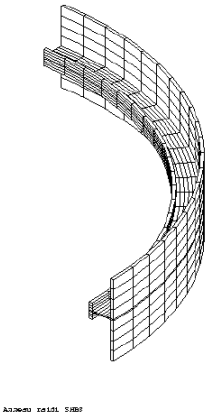
2.4 References

[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 Modelization A

3.1 Characteristic of the modelization

1/4 of the stiffened cylinder:



3.2 Characteristics of the mesh

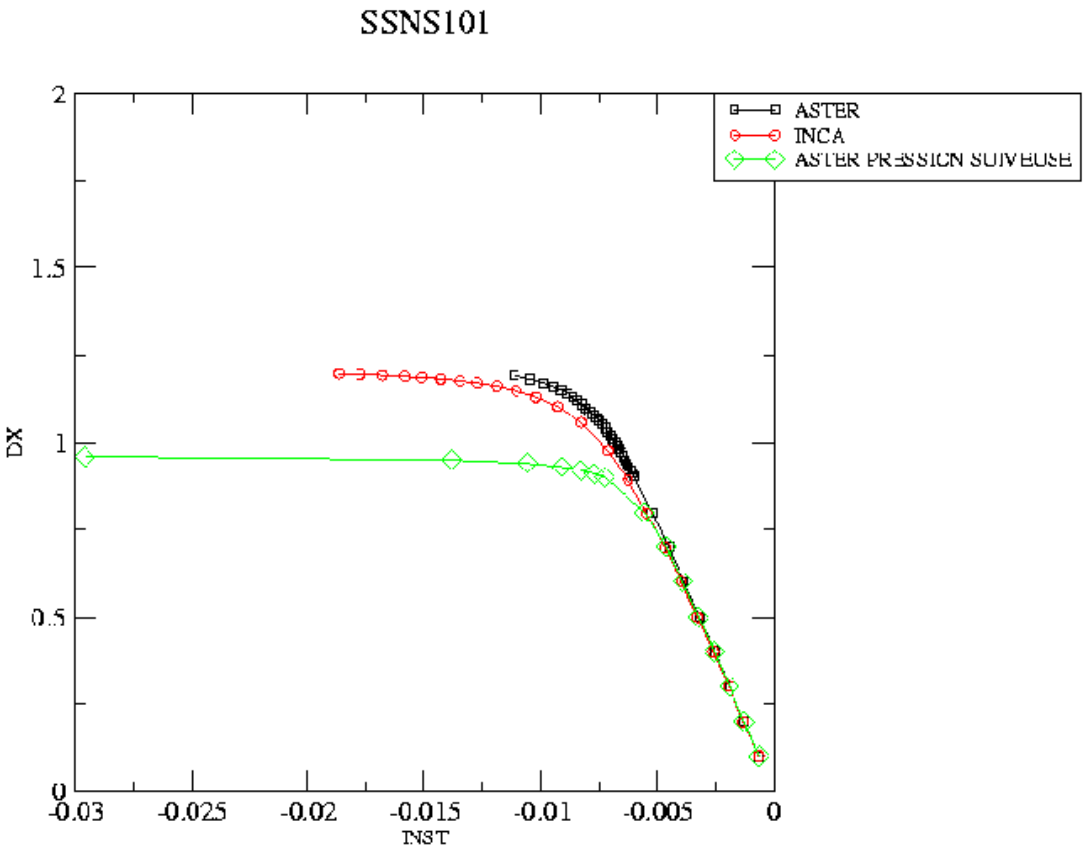
966 nodes, 440 SHB8,
180 QUAD4 (external skin)

3.3 Quantities tested and results

the 1st critical load of Eulerian calculated in "linear elasticity (small displacements) is worth:

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

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



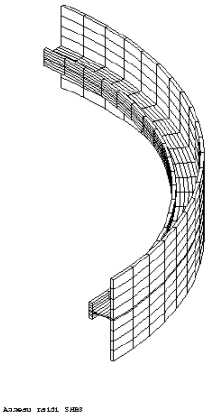
The reference solution (INCA computation without following pressure) is compared with the solution *Aster* in the following table:

Time	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 Modelization B

4.1 Characteristic of the modelization

1/4 of the stiffened cylinder:



4.2 Characteristics of the mesh

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

4.3 Quantities tested and results

the 1st critical load of Eulerian calculated in "linear elasticity (small displacements)" is worth:

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

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

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

Time	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

the results got by *Code_Aster* with elements SHB8 and SHB20 show their capacity with dealing with problems of thin shells with geometric nonlinearities.
The results with nonfollowing pressure are close to those of the reference. They are a little better with the SHB20 than with the SHB8, for the same number of meshes.
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 computations.