SSNS101 – Breakdown of a cylindrical panel under specific force

Abstract:

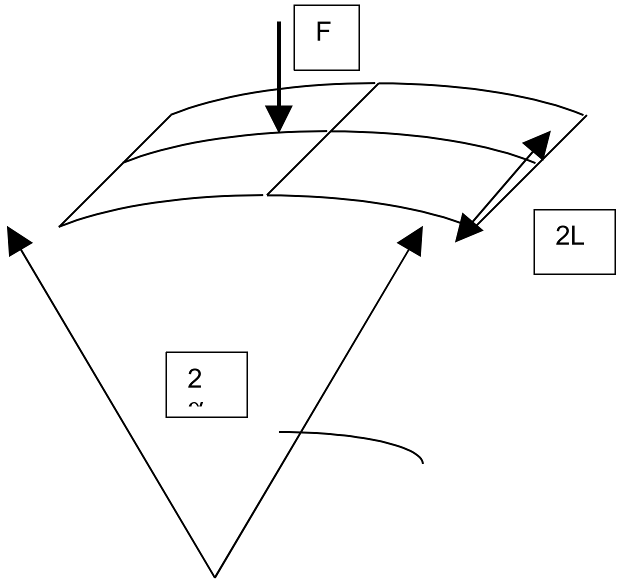
This test of nonlinear quasi-static mechanics makes it possible to validate the elements SHB in nonlinear geometrical and material.

Seven modelizations make it possible to study various configurations:

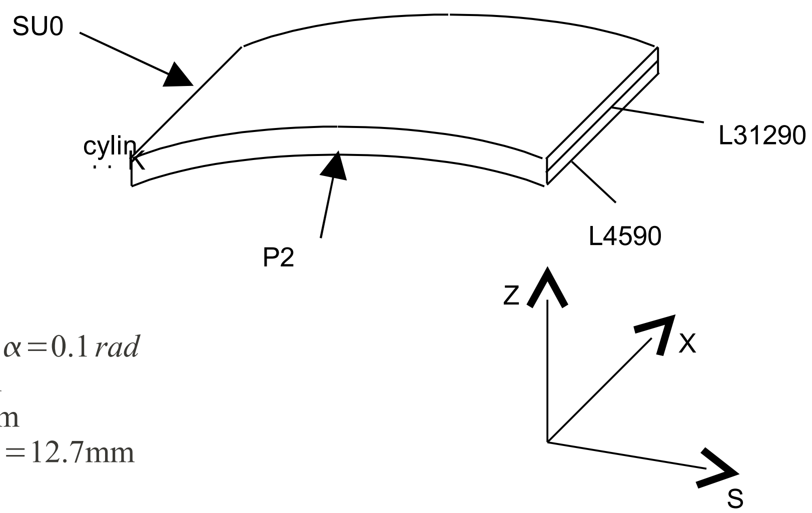
- linear modelization a: elastic behavior, large displacements, bearing on mean surface
- linear modelization b: elastic behavior, large displacements, bearing on surface lower
- modelizations C than G: elastoplastic behavior of Von Mises in linear isotropic hardening, large displacements, bearing on mean surface. Test on all the elements SHB (SHB8, SHB6, SHB20, SHB15)
- modelization H: elastoplastic behavior of Von Mises with mixed hardening.

1Problem of reference

1.1Geometry



One models a quarter of the panel because of symmetries:



- Panel Angle
  - Thickness $2\alpha=0.1\,rad$
  - $L=254\text{mm}$
  - $R=2450\text{mm}$
  - Properties $h=12.7\text{mm}$

1.2of the material

the built-in characteristics are the following ones there:

Elastic characteristics:

$E=3102.75\,MPa$

$NU=0.3$

Curve of tension:

Eps	Sig
1.e-03	3.102
0.1	33.5
1.150	

1.3 Boundary conditions and loadings

Conditions of symmetry on the coasts $SU0$ and $SUSUP$.

Fixed support on the side $L31290$ (what returns in a simple bearing) for the modelizations A and C.
Fixed support on line $L4590$ (simple bearing on the lower part of the shell) for the modelization B.

nodal Force $FX=-0.25\,N$ on the point $P2$. (total resultant in taking into account symmetries: $1\mathrm{N}$).

The loading is controlled by the value of the following displacement X of the point $P2$. The amplitude of the force (coefficient ETA of control) is increased so that displacement grows until $45\,mm$ by step of $1\,mm$.

2Reference solution

2.1numerical

Method of calculating Solution [bib1] [bib2]: values of the parameter of control (thus of the force F) according to time (thus of the displacement DX of the point $P2$).

2.2Quantities and results of reference

Coefficient of control (multiplying coefficient of the applied force) according to the displacement DX of the point $P2$.

In the case of simple modelization a: bearing on the mean surface of the shell: results of reference obtained by a fine modelization in elements HEXA20.

In the case of the modelization B, with conditions of simple support on lower edge of the shell, the curve of reference obtained by the code INCA [bib1] and in [bib2] is:

Displacement	Forces (N) [bib1]	Force (N) [bib2]
2	0.706	0.730
4	1.273	1.315
6	1.707	1.760
8	2.007	2.066
10	2.160	2.221
12	2.129	2.189
14	1.827	1.876
16	1.180	1.178
18	0.677	0.654
20	0.592	0.582

In the case of the modelization C: simple bearing on the mean surface of the shell, in elastoplasticity, the results of reference are got by a fine modelization in elements HEXA20.

2.3Uncertainties on the solution

Without object

2.4References

[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,

[2]"A geometrical non-linear brig element based one the eas method" Kinkel S, Wagner W., International Newspaper for Numerical Methods in Engineering, 40 4529-4545 1997,

3Modelization A

3.1Characteristic of the simple

modelization Bearing on the line average one. Linear elasticity in large displacements.

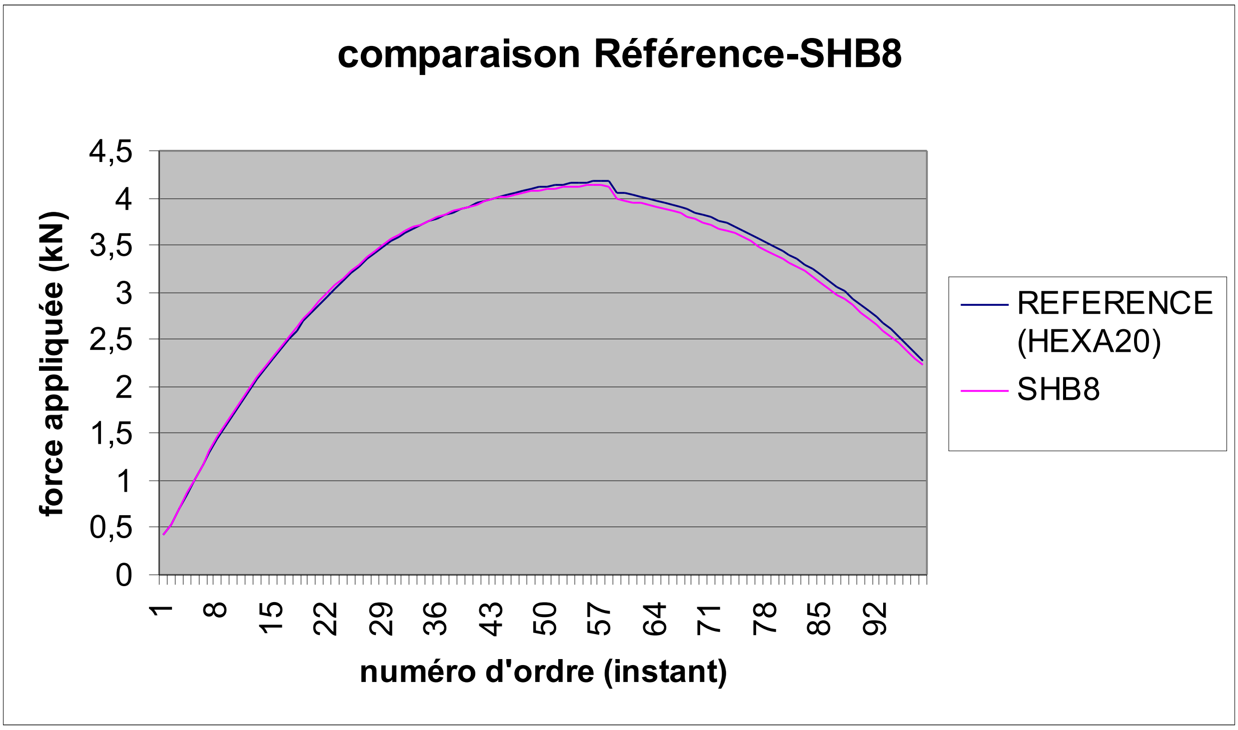
3.2Characteristics of the mesh

Many nodes: 882
Number of meshes and types: 400 HEXA8.

3.3Quantities tested and results of the modelization A

identified Parameters: time, and coefficient of control (applied force):

Time	No of order	*Reference*	*Aster*	*% difference*
8.63300E-01	1	4.18993D+02	4.22272D+02	0.8
6.98600E+00	16	2.39906D+03	2.42292D+03	1.0
1.42000E+01	39	3.88289D+03	3.88237D+03	0.0
2.56900E+01	99	2.27680D+03	2.22150D+03	-2.4



4Modelization B

4.1Characteristic of the modelization

simple Bearing on line the lower. Linear elasticity in large displacements.

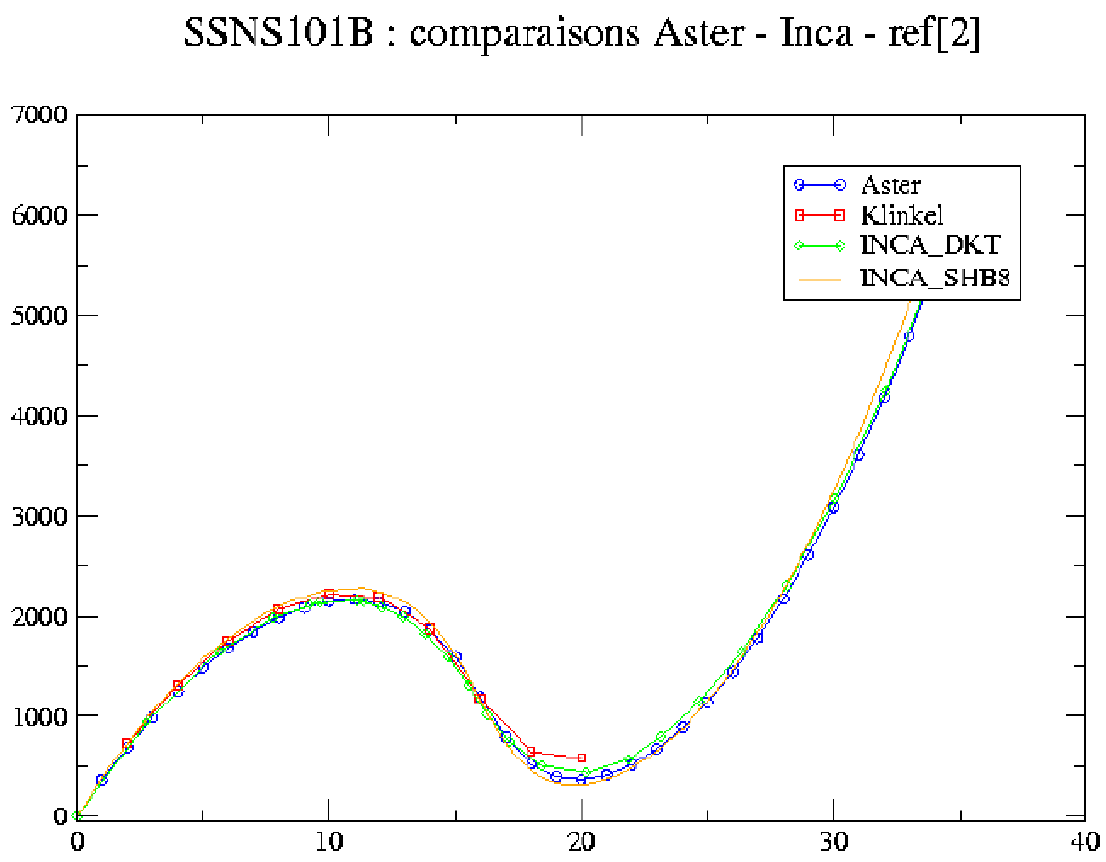
4.2Characteristics of the mesh

Many nodes: 363
Number of meshes and types: 200 HEXA8.

4.3Quantities tested and results of the modelization B

identified Parameters: displacement in x point $P2$, and coefficient of control (values of non regression):

Identification (time)	Values of the displacement DX of the point $P2$	Reference (Kinkel)	*Aster*	% difference
1.00000E+00	-1.00000E+00		3.60312E+02	
2.00000E+00	-2.00000E+00	730	6.87275E+02	-5.9
3.00000E+00	-3.00000E+00		9.81699E+02	
4.00000E+00	-4.00000E+00	1315	1.24418E+03	-5.4
5.00000E+00	-5.00000E+00		1.47503E+03	
6.00000E+00	-6.00000E+00	1760	1.67422E+03	-4.9
7.00000E+00	-7.00000E+00		1.84125E+03	
8.00000E+00	-8.00000E+00	2066	1.97502E+03	-4.4
9.00000E+00	-9.00000E+00		2.07363E+03	
1.00000E+01	-1.00000E+01	2221	2.13403E+03	-3.9
1.10000E+01	-1.10000E+01		2.15151E+03	
1.20000E+01	-1.20000E+01	2189	2.11885E+03	-3.2
1.30000E+01	-1.30000E+01		2.02494E+03	
1.40000E+01	-1.40000E+01	1876	1.85295E+03	-1.2
1.50000E+01	-1.50000E+01		1.58130E+03	
1.60000E+01	-1.60000E+01	1178	1.20791E+03	2.5
1.70000E+01	-1.70000E+01		8.27119E+02	
1.80000E+01	-1.80000E+01	654	5.73607E+02	-12.3
1.90000E+01	-1.90000E+01		4.56884E+02	
2.00000E+01	-2.00000E+01	582	4.40786E+02	-24.3
2.10000E+01	-2.10000E+01		5.00336E+02	
2.20000E+01	-2.20000E+01		6.21418E+02	
2.30000E+01	-2.30000E+01		7.95936E+02	
2.40000E+01	-2.40000E+01		1.01907E+03	
2.50000E+01	-2.50000E+01		1.28785E+03	
2.60000E+01	-2.60000E+01		1.60043E+03	
2.70000E+01	-2.70000E+01		1.95566E+03	
2.80000E+01	-2.80000E+01		2.35281E+03	
2.90000E+01	-2.90000E+01		2.79147E+03	


SSNS101B : comparaisons Aster - Inca - ref[2]
7000
6000
5000
4000
3000
2000
1000
0
0
10
20
30
40
Aster
Klinkel
INCA_DKT
INCA_SHB8

5Modelization C

5.1Characteristic of the simple

modelization Bearing on the line average one. Elastoplasticity of Von Mises with linear isotropic hardening in large displacements.

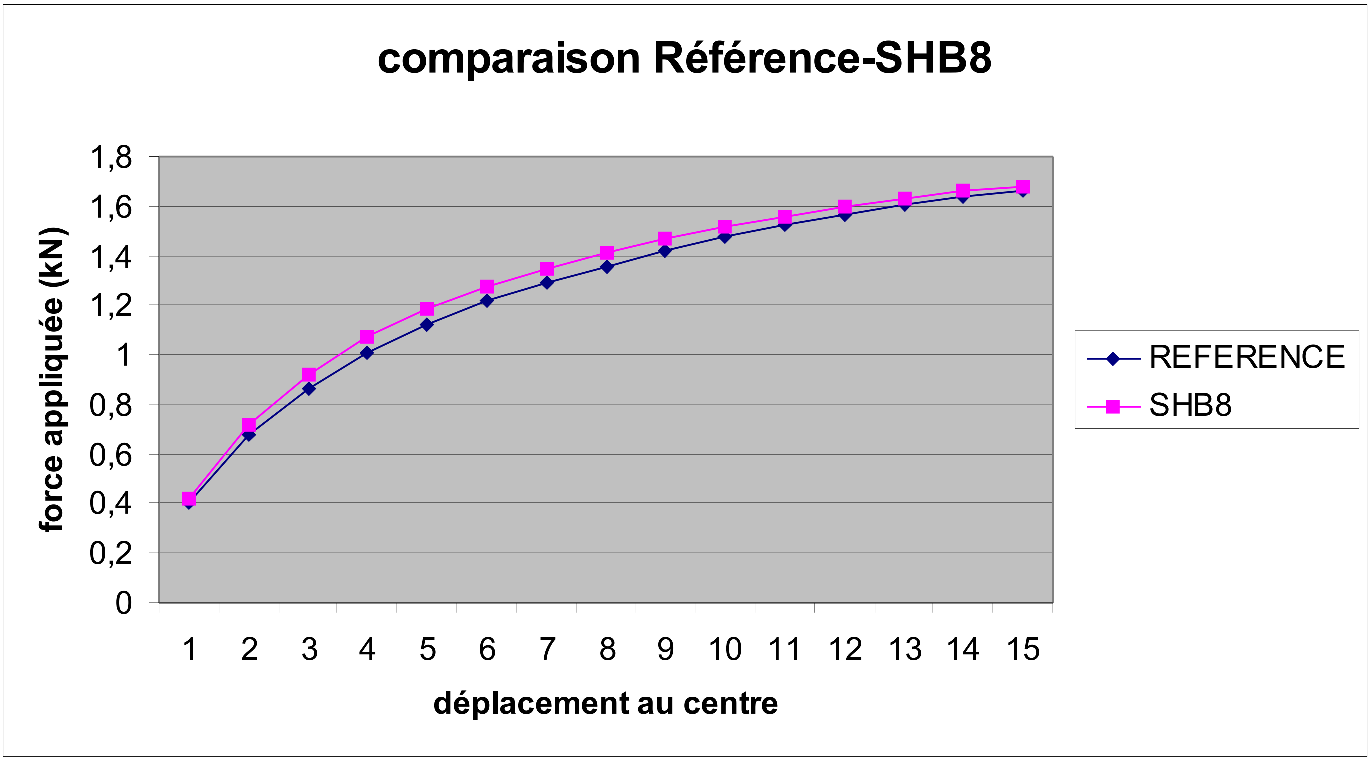
5.2Characteristics of the mesh

Many nodes: 242
Number of meshes and types: 100 HEXA8.

5.3Quantities tested and results of the modelization C

identified Parameters: displacement in x point $P2$, and coefficient of control:.

Displacement at the point $P2$	Applied force at the point $P2$	*Reference*	*Aster*	*% difference*
1.00000E+00	-1.00000E+00	0.40541 E+03	0.41661 E+03	2.8
2.00000E+00	-2.00000E+00	0.67551 E+03	0.71639 E+03	6.0
3.00000E+00	-3.00000E+00	0.86633 E+03	0.92294 E+03	6.5
4.00000E+00	-4.00000E+00	1.01265 E+03	1.07396 E+03	6.5
5.00000E+00	-5.00000E+00	1.12588 E+03	1.18775 E+03	5.5
6.00000E+00	-6.00000E+00	1.21543 E+03	1.27632 E+03	5.0
7.00000E+00	-7.00000E+00	1.29151 E+03	1.34929 E+03	4.5
8.00000E+00	-8.00000E+00	1.35855 E+03	1.41255 E+03	4.0
9.00000E+00	-9.00000E+00	1.41888 E+03	1.46841 E+03	3.5
1.00000E+01	-1.00000E+01	1.47379 E+03	1.51817 E+03	3.0
1.10000E+01	-1.10000E+01	1.52345 E+03	1.56157 E+03	2.5
1.20000E+01	-1.20000E+01	1.56775 E+03	1.59927 E+03	2.0
1.30000E+01	-1.30000E+01	1.60583 E+03	1.63210 E+03	1.6
1.40000E+01	-1.40000E+01	1.63667 E+03	1.65984 E+03	1.4
1.50000E+01	-1.50000E+01	1.66105 E+03	1.67966 E+03	1.1


comparaison Référence-SHB8
force appliquée (kN)
1,8
1,6
1,4
1,2
1
0,8
0,6
0,4
0,2
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
déplacement au centre
REFERENCE
SHB8

6Modelization D

6.1Characteristic of simple

modelization Bearing on the line average one. Elastoplasticity of Von Mises with linear isotropic hardening in large displacements.

6.2Characteristics of the mesh

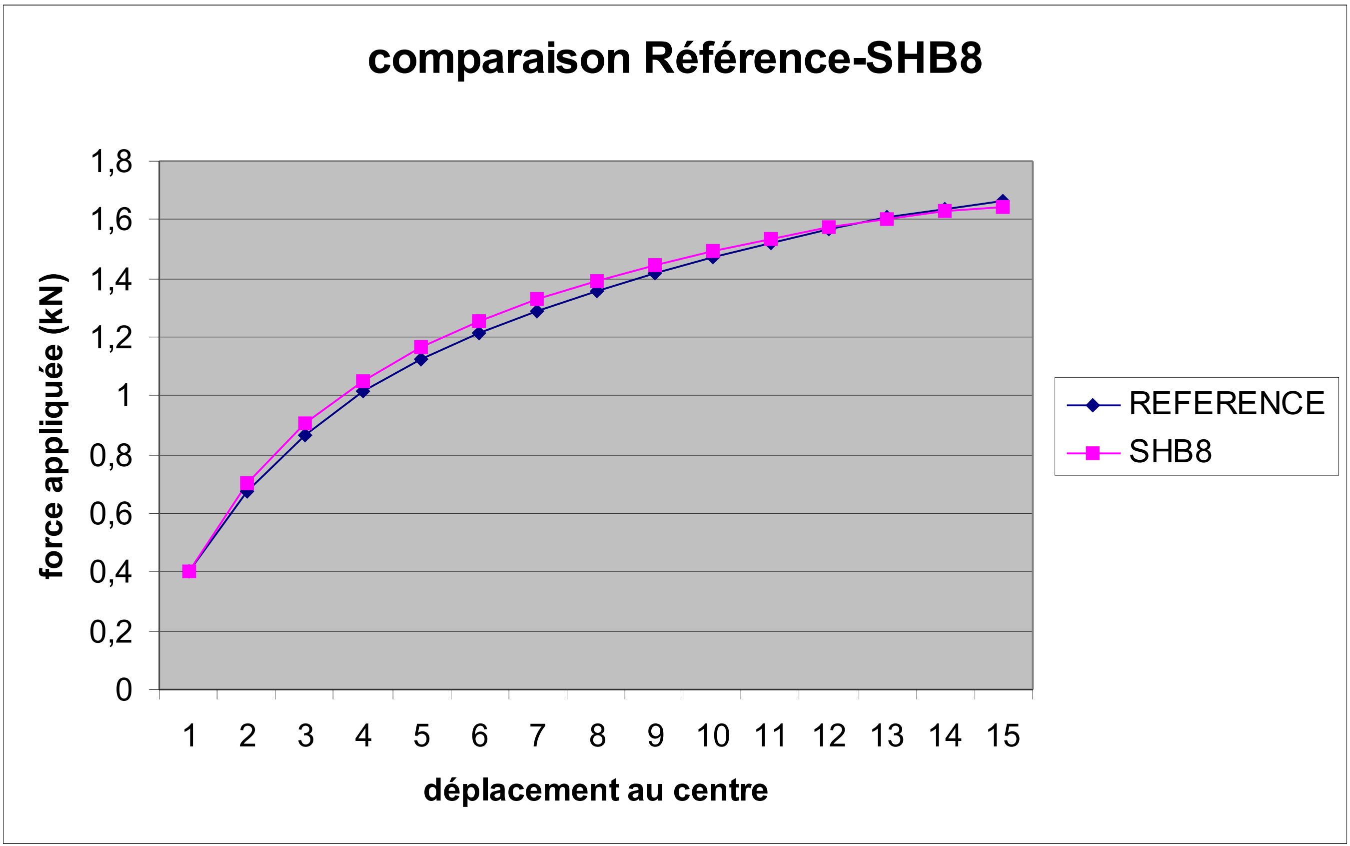
One refines the mesh compared to the modelization C. One takes 30 elements on the circumference, 30 in-depth elements and 2 elements in the thickness.

Many nodes: 2883
Number of meshes and types: 1800 HEXA8.

6.3Quantities tested and results of the modelization D

identified Parameters: displacement in x point $P2$, and coefficient of control:.

Displacement at the point $P2$	**Applied force at the point** $P2$	***Reference***	***Aster***	***% difference***
1.00000E+00	-1.00000E+00	0.40541 E+03	0,39933 E+03	1.5
2.00000E+00	-2.00000E+00	0.67551 E+03	0,69965 E+03	3.6
3.00000E+00	-3.00000E+00	0.86633 E+03	0,90385 E+03	4.3
4.00000E+00	-4.00000E+00	1.01265 E+03	1,05258 E+03	3.9
5.00000E+00	-5.00000E+00	1.12588 E+03	1,16509 E+03	3.5
6.00000E+00	-6.00000E+00	1.21543 E+03	1,25463 E+03	3.2
7.00000E+00	-7.00000E+00	1.29151 E+03	1,32818 E+03	2.8
8.00000E+00	-8.00000E+00	1.35855 E+03	1,39118 E+03	2.4
9.00000E+00	-9.00000E+00	1.41888 E+03	1,44619 E+03	1.9
1.00000E+01	-1.00000E+01	1.47379 E+03	1,49419 E+03	1.4
1.10000E+01	-1.10000E+01	1.52345 E+03	1,53611 E+03	0.8
1.20000E+01	-1.20000E+01	1.56775 E+03	1,57259 E+03	0.3
1.30000E+01	-1.30000E+01	1.60583 E+03	1,60294 E+03	-0.2
1.40000E+01	-1.40000E+01	1.63667 E+03	1,62674 E+03	-0.6
1.50000E+01	-1.50000E+01	1.66105 E+03	1,64314 E+03	-1.1


comparaison Référence-SHB8
force appliquée (kN)
1,8
1,6
1,4
1,2
1
0,8
0,6
0,4
0,2
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
déplacement au centre
REFERENCE
SHB8

7Modelization E

7.1Characteristic of simple

modelization Bearing on the line average one. Elastoplasticity of Von Mises with linear isotropic hardening in large displacements.

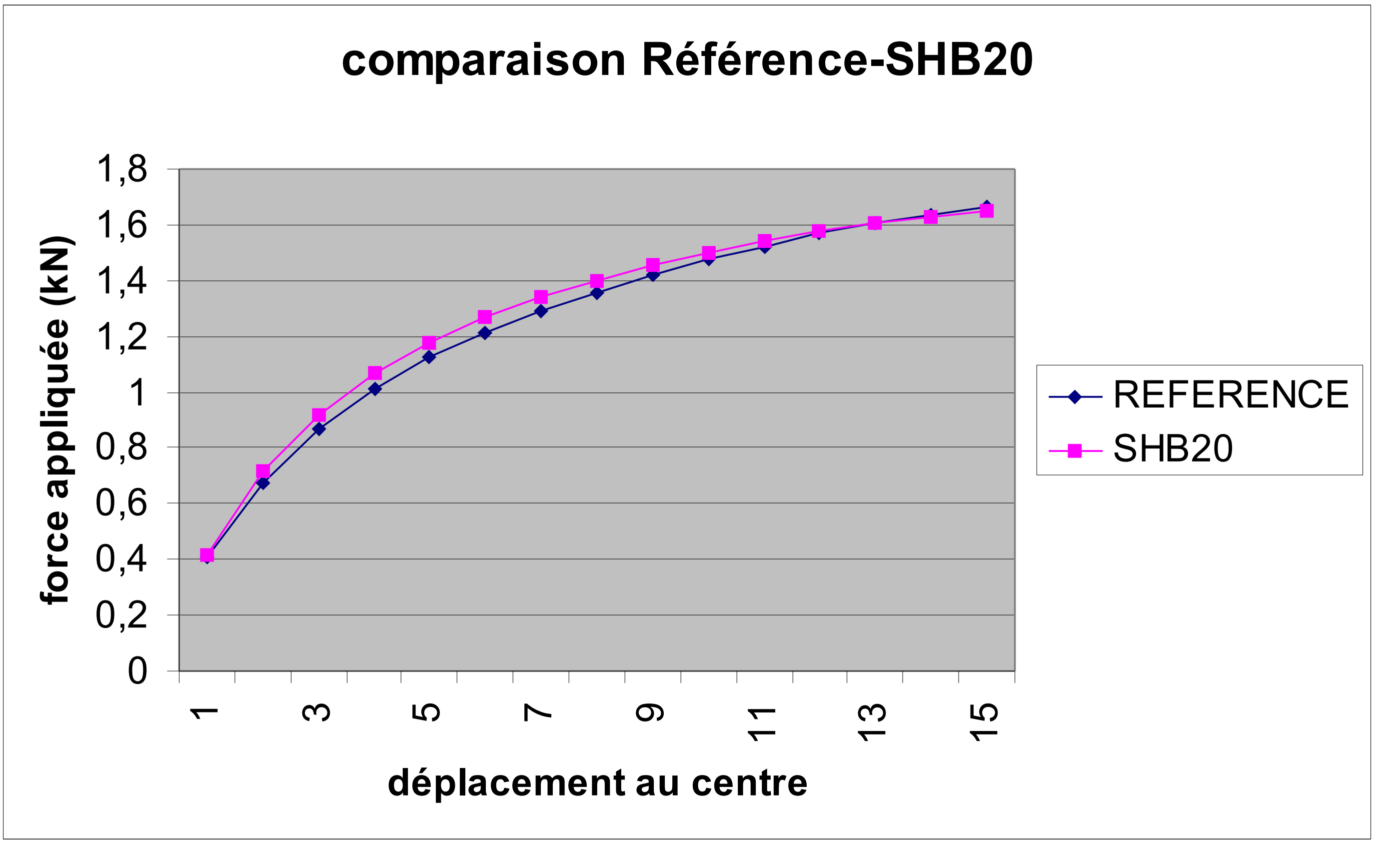
7.2Characteristics of the mesh

Many nodes: 3003
Number of meshes and types: 400 SHB20.

7.3Quantities tested and results of the modelization E

identified Parameters: displacement in x point $P2$, and coefficient of control:.

Displacement at the point $P2$	**Applied force at the point** $P2$	***Reference***	***Aster***	***% difference***
1.00000E+00	-1.00000E+00	0.40541 E+03	4.12366E+02	1.7
2.00000E+00	-2.00000E+00	0.67551 E+03	7.13789E+02	5.7
3.00000E+00	-3.00000E+00	0.86633 E+03	9.17652E+02	5.9
4.00000E+00	-4.00000E+00	1.01265 E+03	1.06608E+03	5.3
5.00000E+00	-5.00000E+00	1.12588 E+03	1.17837E+03	4.7
6.00000E+00	-6.00000E+00	1.21543 E+03	1.26623E+03	4.2
7.00000E+00	-7.00000E+00	1.29151 E+03	1.33809E+03	4.5
8.00000E+00	-8.00000E+00	1.35855 E+03	1.39974E+03	3.6
9.00000E+00	-9.00000E+00	1.41888 E+03	1.45378E+03	3.0
1.00000E+01	-1.00000E+01	1.47379 E+03	1.50129E+03	2.5
1.10000E+01	-1.10000E+01	1.52345 E+03	1.54211E+03	2.5
1.20000E+01	-1.20000E+01	1.56775 E+03	1.57712E+03	1.9
1.30000E+01	-1.30000E+01	1.60583 E+03	1.60671E+03	1.2
1.40000E+01	-1.40000E+01	1.63667 E+03	1.63073E+03	0.6
1.50000E+01	-1.50000E+01	1.66105 E+03	1.64715E+03	-0.8


comparaison Référence-SHB20
force appliquée (kN)
1,8
1,6
1,4
1,2
1
0,8
0,6
0,4
0,2
0
1
3
5
7
9
11
13
15
déplacement au centre
REFERENCE
SHB20

8Modelization F

8.1Characteristic of the simple

modelization Bearing on the line average one. Elastoplasticity of Von Mises with linear isotropic hardening in large displacements.

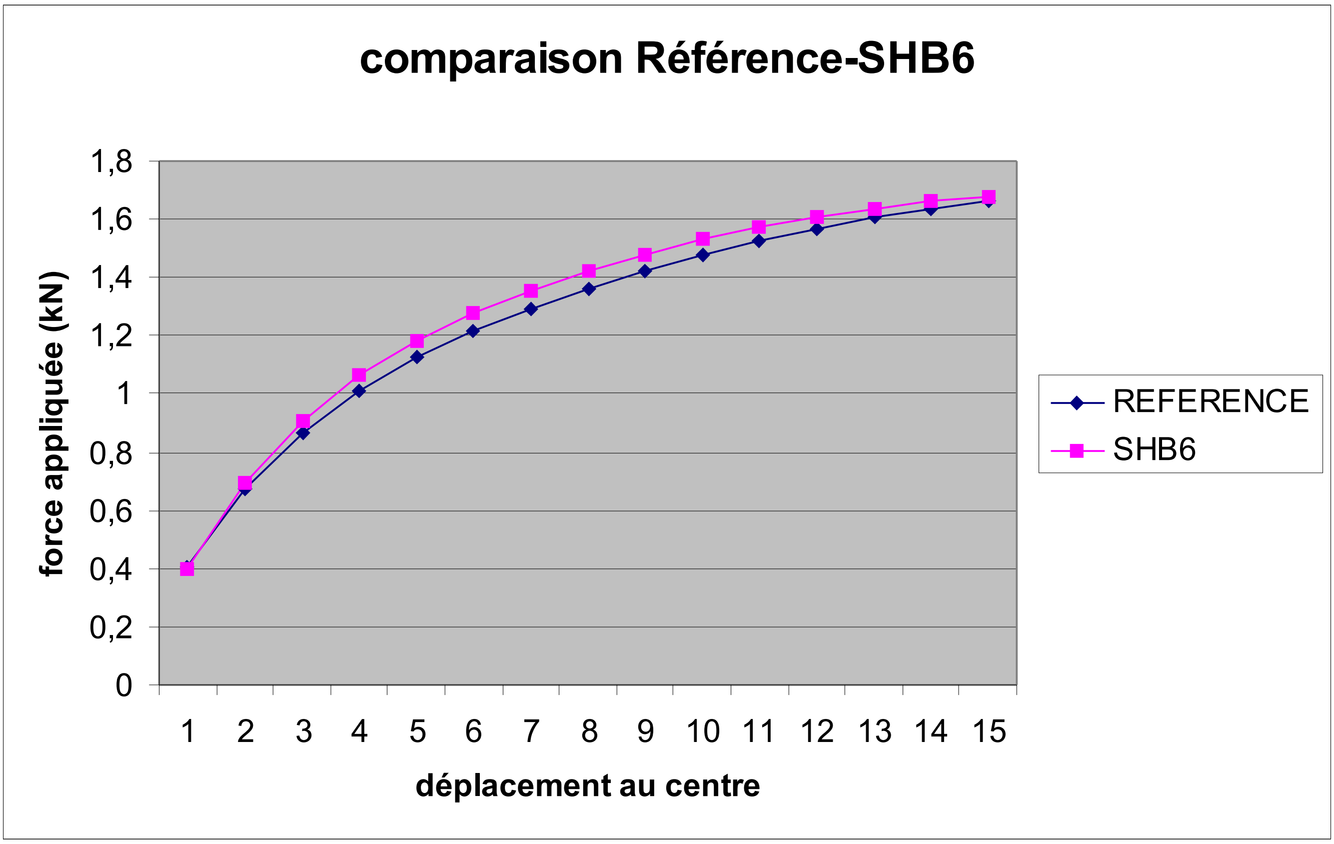
8.2Characteristics of the mesh

Many nodes: 1922
Number of meshes and types: 1800 SHB6.

8.3Quantities tested and results of the modelization F

identified Parameters: displacement in x point $P2$, and coefficient of control:.

Displacement at the point $P2$	Applied force at the point $P2$	*Reference*	*Aster*	*% difference*
1.00000E+00	-1.00000E+00	0.40541 E+03	3.97288E+02	-2.0
2.00000E+00	-2.00000E+00	0.67551 E+03	6.94789E+02	2.8
3.00000E+00	-3.00000E+00	0.86633 E+03	9.04255E+02	4.4
4.00000E+00	-4.00000E+00	1.01265 E+03	1.06164E+03	4.8
5.00000E+00	-5.00000E+00	1.12588 E+03	1.18219E+03	5.0
6.00000E+00	-6.00000E+00	1.21543 E+03	1.27698E+03	5.1
7.00000E+00	-7.00000E+00	1.29151 E+03	1.35469E+03	4.9
8.00000E+00	-8.00000E+00	1.35855 E+03	1.42122E+03	4.6
9.00000E+00	-9.00000E+00	1.41888 E+03	1.47931E+03	4.3
1.00000E+01	-1.00000E+01	1.47379 E+03	1.52998E+03	3.8
1.10000E+01	-1.10000E+01	1.52345 E+03	1.57302E+03	3.3
1.20000E+01	-1.20000E+01	1.56775 E+03	1.60858E+03	2.6
1.30000E+01	-1.30000E+01	1.60583 E+03	1.63766E+03	2.0
1.40000E+01	-1.40000E+01	1.63667 E+03	1.65996E+03	1.4
1.50000E+01	-1.50000E+01	1.66105 E+03	1.67375E+03	0.8


comparaison Référence-SHB6
force appliquée (kN)
1,8
1,6
1,4
1,2
1
0,8
0,6
0,4
0,2
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
déplacement au centre
REFERENCE
SHB6

9Modelization G

9.1Characteristic of the simple

modelization Bearing on the line average one. Elastoplasticity of Von Mises with linear isotropic hardening in large displacements.

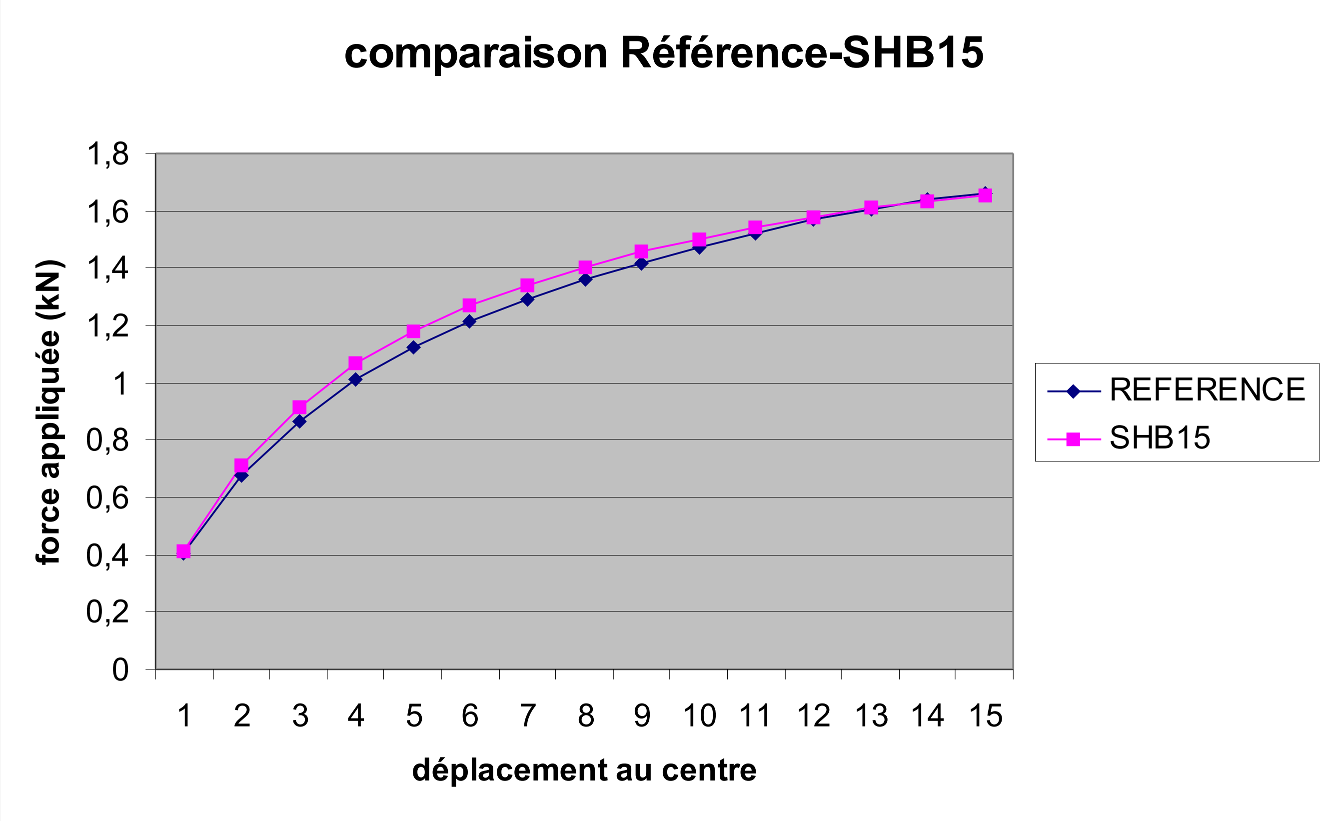
9.2Characteristics of the mesh

Many nodes: 3803
Number of meshes and types: 1800 SHB15.

9.3Quantities tested and results of the modelization G

identified Parameters: displacement in x point $P2$, and coefficient of control:.

Displacement at the point $P2$	**Applied force at the point** $P2$	***Reference***	***Aster***	***% difference***
1.00000E+00	-1.00000E+00	0.40541 E+03	4.10504E+02	1.3
2.00000E+00	-2.00000E+00	0.67551 E+03	7.10013E+02	5.1
3.00000E+00	-3.00000E+00	0.86633 E+03	9.15540E+02	5.7
4.00000E+00	-4.00000E+00	1.01265 E+03	1.06624E+03	5.3
5.00000E+00	-5.00000E+00	1.12588 E+03	1.17957E+03	4.8
6.00000E+00	-6.00000E+00	1.21543 E+03	1.26755E+03	4.3
7.00000E+00	-7.00000E+00	1.29151 E+03	1.33913E+03	4.5
8.00000E+00	-8.00000E+00	1.35855 E+03	1.40080E+03	3.7
9.00000E+00	-9.00000E+00	1.41888 E+03	1.45503E+03	3.1
1.00000E+01	-1.00000E+01	1.47379 E+03	1.50296E+03	2.5
1.10000E+01	-1.10000E+01	1.52345 E+03	1.54419E+03	2.0
1.20000E+01	-1.20000E+01	1.56775 E+03	1.57950E+03	1.4
1.30000E+01	-1.30000E+01	1.60583 E+03	1.60935E+03	0.7
1.40000E+01	-1.40000E+01	1.63667 E+03	1.63372E+03	-0.2
1.50000E+01	-1.50000E+01	1.66105 E+03	1.65064E+03	-0.6


comparaison Référence-SHB15
force appliquée (kN)
1,8
1,6
1,4
1,2
1
0,8
0,6
0,4
0,2
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
déplacement au centre
REFERENCE
SHB15

10Modelization H

10.1Characteristic of the modelization

Modelization identical to the modelization C, except the behavior. One chose here elastoplasticity of Von Mises with mixed hardening: isotropic linear and kinematical linear (with a coefficient of null Prager), in order to test the possibility of using various behaviors.

10.2Characteristics of the mesh

Many nodes: 242
Number of meshes and types: 100 HEXA8.

10.3Quantities tested and results of the modelization C

identified Parameters: displacement in x of the point $P2$, and coefficient of control:.

Displacement at the point $P2$	Applied force at the point $P2$	*2.5*	*Reference*	*Aster %*
difference	1.00000E+00	-1.00000E+00 0.40541	E+03 0.41661	E+03
2.8	2.00000E+00	-2.00000E+00 0.67551	E+03 0.71639	E+03
6.0	3.00000E+00	-3.00000E+00 0.86633	E+03 0.92294	E+03
6.5	4.00000E+00	-4.00000E+00 1.01265	E+03 1.07396	E+03
6.5	5.00000E+00	-5.00000E+00 1.12588	E+03 1.18775	E+03
5.5	6.00000E+00	-6.00000E+00 1.21543	E+03 1.27632	E+03
5.0	7.00000E+00	-7.00000E+00 1.29151	E+03 1.34929	E+03
4.5	8.00000E+00	-8.00000E+00 1.35855	E+03 1.41255	E+03
4.0	9.00000E+00	-9.00000E+00 1.41888	E+03 1.46841	E+03
3.5	1.00000E+01	-1.00000E+01 1.47379	E+03 1.51817	E+03
3.0	1.10000E+01	-1.10000E+01 1.52345	E+03 1.56157	E+03
1.20000E+01	-1.20000E+01	1.56775 E+03	1.59927 E+03	2.0
1.30000E+01	-1.30000E+01	1.60583 E+03	1.63210 E+03	1.6
1.40000E+01	-1.40000E+01	1.63667 E+03	1.65984 E+03	1.4
1.50000E+01	-1.50000E+01	1.66105 E+03	1.67966 E+03	the 1.1

results are identical to those of the modelization C, which was expected.

11Summary of the results

the results got by *Code_Aster* with modelization SHB show the capacity of all the elements of this modelization to dealing with problems of shells thin with geometric nonlinearities and behavioral.