SSNS101 – Breakdown of a cylindrical panel under specific force

Summary:

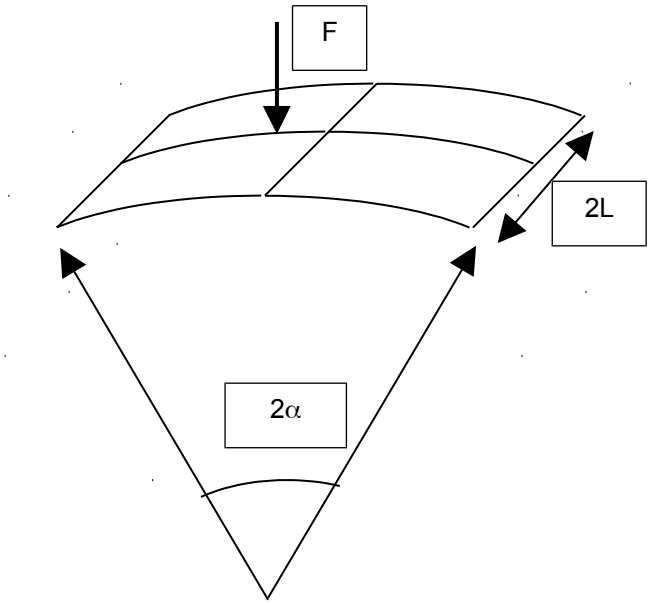
This test of nonlinear quasi-static mechanics makes it possible to validate the elements SHB into nonlinear geometrical and material.

Seven modelings make it possible to study various configurations:

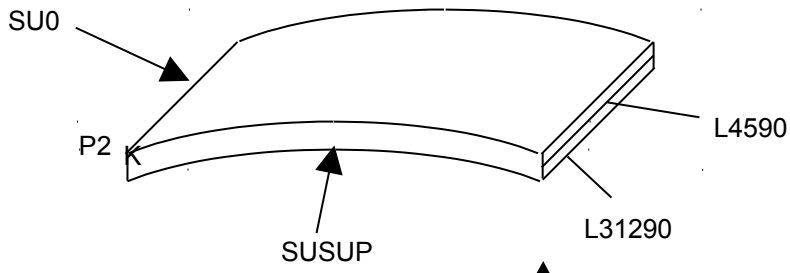
- linear modeling a: elastic behavior, great displacements, support on average surface
- linear modeling b: elastic behavior, great displacements, support on lower surface
- modelings C with G: elastoplastic behavior of Von Mises with linear isotropic work hardening, great displacements, support on average surface. Test on all elements SHB (SHB8, SHB6, SHB20, SHB15)
- modeling H: elastoplastic behavior of Von Mises with mixed work hardening.

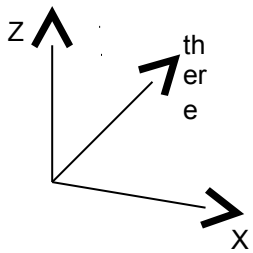
1Problem of reference

1.1Geometry



One models a quarter of the panel because of symmetries:





•Cylindrical panel
-Angle $alpha=0.1\,rad$
- $L=254\text{mm}$
- $R=2540\text{mm}$
-Thickness $h=12.7\text{mm}$

1.2Properties of material

The fixed characteristics are the following ones:

Elastic characteristics:

$E=3102.75\,MPa$
$NU=0.3$

Traction diagram:

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 $SUSUP$.

Embedding on the side $L31290$ (what returns in a simple support) for modelings A and C.
Embedding on the line $L4590$ (simple support on the lower part of the hull) for modeling B.

Nodal force $FX=-0.25\,N$ on the point $P2$. (total resultant by taking of account symmetries: $1\mathrm{N}$).

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

2Reference solution

2.1Method of calculating

Digital solution [bib1] [bib2]: values of the parameter of piloting (thus of the force F) according to the time (thus of displacement DX point $P2$).

2.2Sizes and results of reference

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

In the case of simple modeling a: support on the average surface of the hull: results of reference obtained by a fine modeling in elements HEXA20.

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

Displacement	Force (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 modeling C: simple support on the average surface of the hull, in elastoplasticity, the results from reference are obtained by a fine modeling 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]"With 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,

3Modeling A

3.1Characteristics of modeling

Simple support on the average line. Linear elasticity in great displacements.

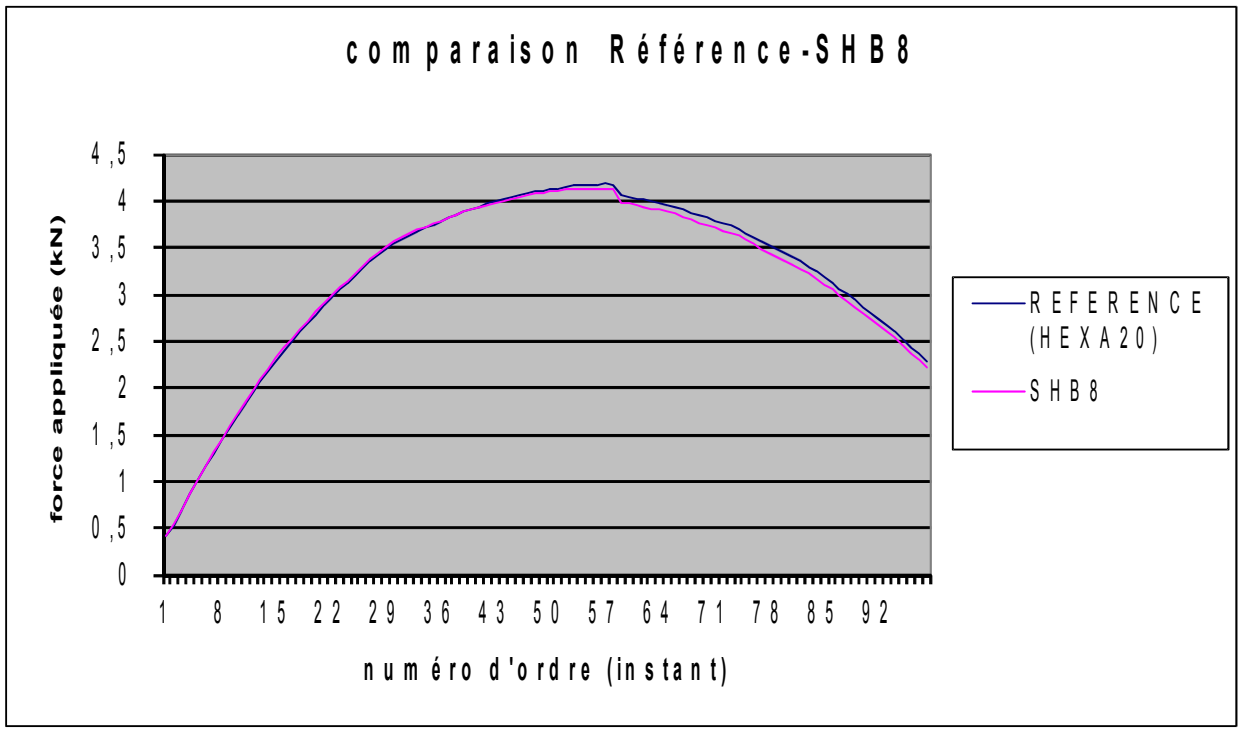
3.2Characteristics of the grid

Many nodes: 882
Many meshs and types: 400 HEXA8.

3.3Sizes tested and results of modeling A

Identified parameters: moment, and coefficient of piloting (force applied):

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



4Modeling B

4.1Characteristics of modeling

Simple support on the lower line. Linear elasticity in great displacements.

4.2Characteristics of the grid

Many nodes: 363
Many meshs and types: 200 HEXA8.

4.3Sizes tested and results of modeling B

Identified parameters: displacement in x point $P2$, and coefficient of piloting (values of nonregression):

Identification (moment)	Values of displacement DX point $P2$	Reference (Kinkel)	% difference
1.00000E+00	-1.00000E+00		
2.00000E+00	-2.00000E+00	730	-5.9
3.00000E+00	-3.00000E+00		
4.00000E+00	-4.00000E+00	1315	-5.4
5.00000E+00	-5.00000E+00		
6.00000E+00	-6.00000E+00	1760	-4.9
7.00000E+00	-7.00000E+00		
8.00000E+00	-8.00000E+00	2066	-4.4
9.00000E+00	-9.00000E+00		
1.00000E+01	-1.00000E+01	2221	-3.9
1.10000E+01	-1.10000E+01		
1.20000E+01	-1.20000E+01	2189	-3.2
1.30000E+01	-1.30000E+01		
1.40000E+01	-1.40000E+01	1876	-1.2
1.50000E+01	-1.50000E+01		
1.60000E+01	-1.60000E+01	1178	2.5
1.70000E+01	-1.70000E+01		
1.80000E+01	-1.80000E+01	654	-12.3
1.90000E+01	-1.90000E+01		
2.00000E+01	-2.00000E+01	582	-24.3
2.10000E+01	-2.10000E+01		
2.20000E+01	-2.20000E+01		
2.30000E+01	-2.30000E+01		
2.40000E+01	-2.40000E+01		
2.50000E+01	-2.50000E+01		
2.60000E+01	-2.60000E+01		
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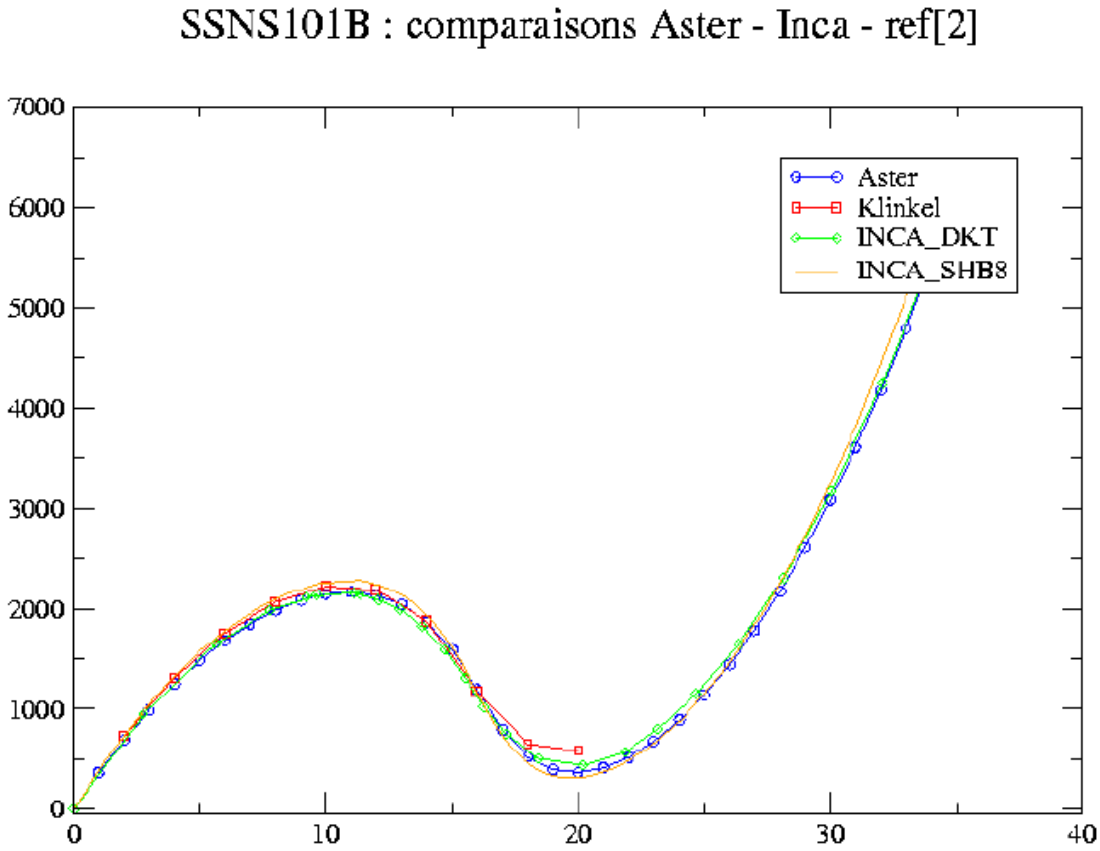
2.80000E+01	-2.80000E+01		
2.90000E+01	-2.90000E+01		



5Modeling C

5.1Characteristics of modeling

Simple support on the average line. Elastoplasticity of Von Mises with linear isotropic work hardening in great displacements.

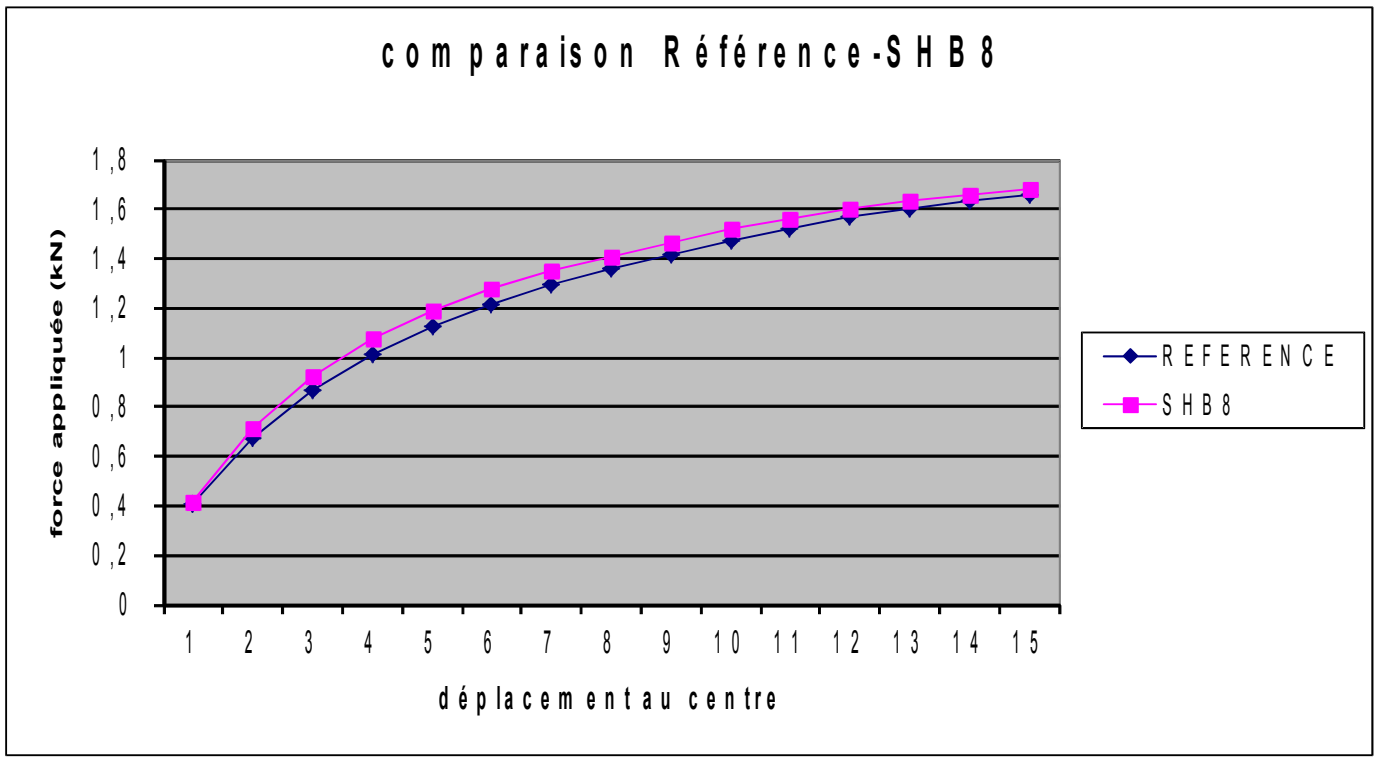
5.2Characteristics of the grid

Many nodes: 242
Many meshs and types: 100 HEXA8.

5.3Sizes tested and results of modeling C

Identified parameters: displacement in x point $P2$, and coefficient of piloting:.

Displacement at the point $P2$	Force applied at the point $P2$	*Reference*	*% difference*
1.00000E+00	-1.00000E+00	0.40541 E+03	2.8
2.00000E+00	-2.00000E+00	0.67551 E+03	6.0
3.00000E+00	-3.00000E+00	0.86633 E+03	6.5
4.00000E+00	-4.00000E+00	1.01265 E+03	6.5
5.00000E+00	-5.00000E+00	1.12588 E+03	5.5
6.00000E+00	-6.00000E+00	1.21543 E+03	5.0
7.00000E+00	-7.00000E+00	1.29151 E+03	4.5
8.00000E+00	-8.00000E+00	1.35855 E+03	4.0
9.00000E+00	-9.00000E+00	1.41888 E+03	3.5
1.00000E+01	-1.00000E+01	1.47379 E+03	3.0
1.10000E+01	-1.10000E+01	1.52345 E+03	2.5
1.20000E+01	-1.20000E+01	1.56775 E+03	2.0
1.30000E+01	-1.30000E+01	1.60583 E+03	1.6
1.40000E+01	-1.40000E+01	1.63667 E+03	1.4
1.50000E+01	-1.50000E+01	1.66105 E+03	1.1



6Modeling D

6.1Characteristics of modeling

Simple support on the average line. Elastoplasticity of Von Mises with linear isotropic work hardening in great displacements.

6.2Characteristics of the grid

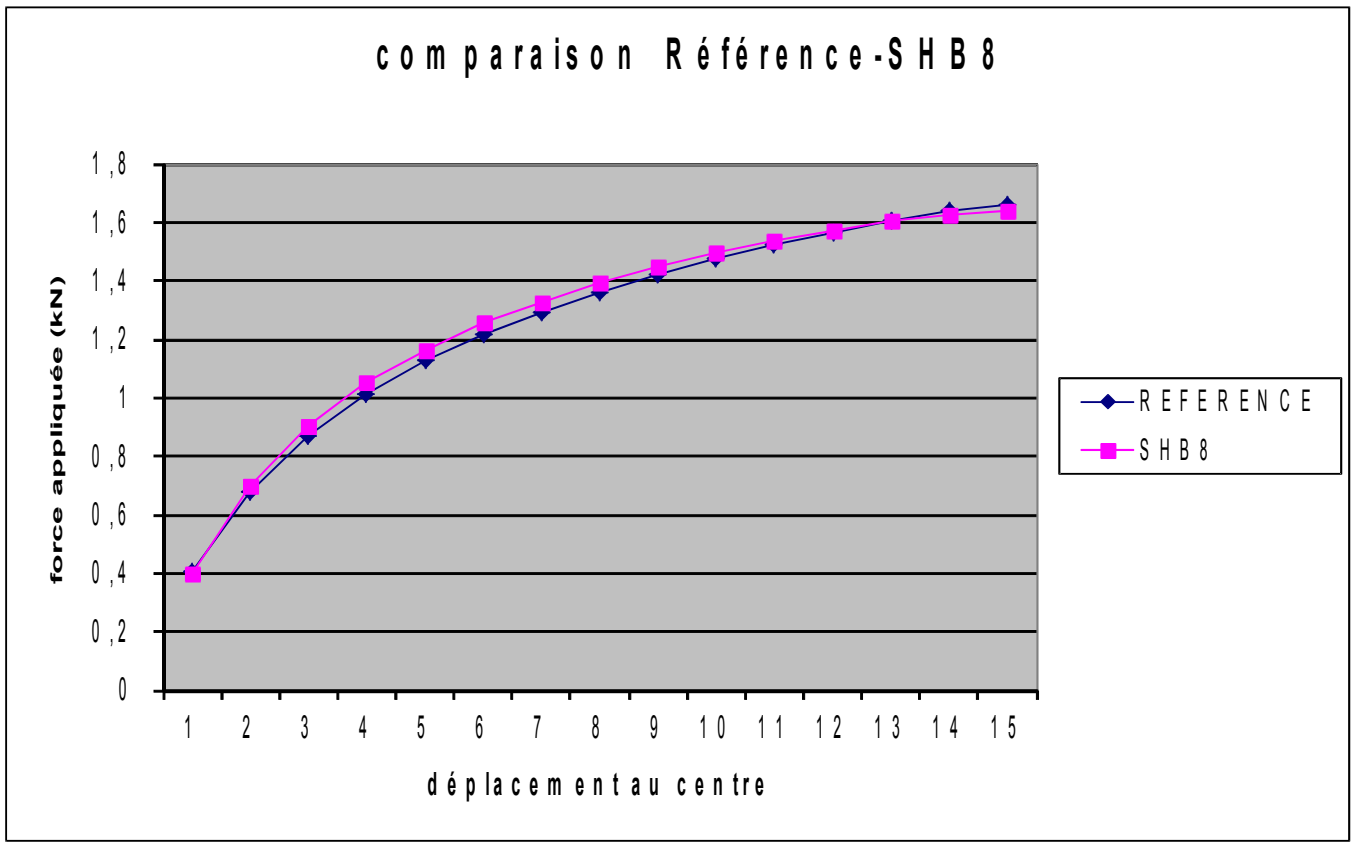
One refines the grid compared to modeling C. One takes 30 elements on the circumference, 30 in-depth elements and 2 elements in the thickness.

Many nodes: 2883
Many meshs and types: 1800 HEXA8.

6.3Sizes tested and results of modeling D

Identified parameters: displacement in x point $P2$, and coefficient of piloting:.

Displacement at the point $P2$	Force applied at the point $P2$	*Reference*	*% difference*
1.00000E+00	-1.00000E+00	0.40541 E+03	1.5
2.00000E+00	-2.00000E+00	0.67551 E+03	3.6
3.00000E+00	-3.00000E+00	0.86633 E+03	4.3
4.00000E+00	-4.00000E+00	1.01265 E+03	3.9
5.00000E+00	-5.00000E+00	1.12588 E+03	3.5
6.00000E+00	-6.00000E+00	1.21543 E+03	3.2
7.00000E+00	-7.00000E+00	1.29151 E+03	2.8
8.00000E+00	-8.00000E+00	1.35855 E+03	2.4
9.00000E+00	-9.00000E+00	1.41888 E+03	1.9
1.00000E+01	-1.00000E+01	1.47379 E+03	1.4
1.10000E+01	-1.10000E+01	1.52345 E+03	0.8
1.20000E+01	-1.20000E+01	1.56775 E+03	0.3
1.30000E+01	-1.30000E+01	1.60583 E+03	-0.2
1.40000E+01	-1.40000E+01	1.63667 E+03	-0.6
1.50000E+01	-1.50000E+01	1.66105 E+03	-1.1



7Modeling E

7.1Characteristics of modeling

Simple support on the average line. Elastoplasticity of Von Mises with linear isotropic work hardening in great displacements.

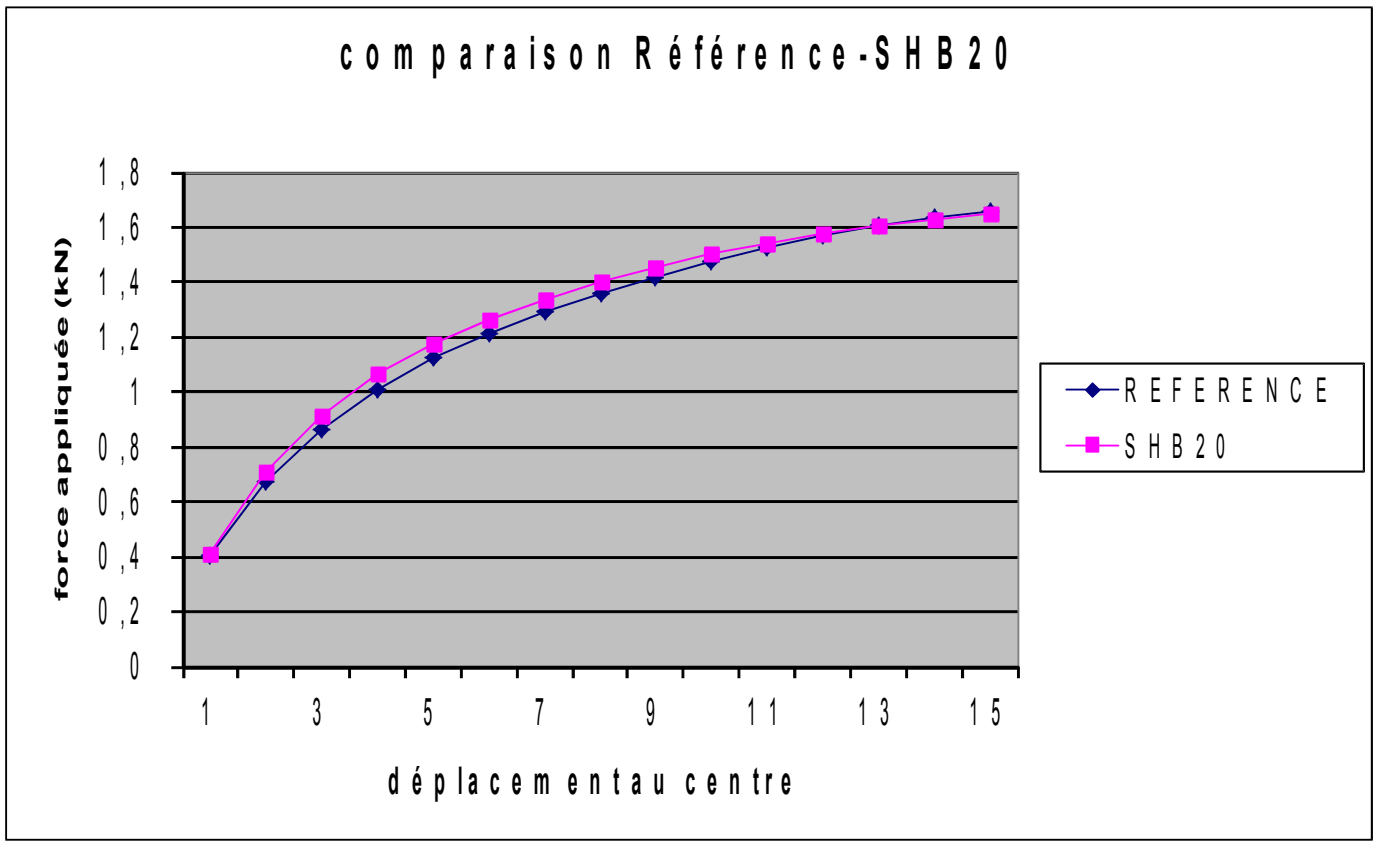
7.2Characteristics of the grid

Many nodes: 3003
Many meshs and types: 400 SHB20.

7.3Sizes tested and results of modeling E

Identified parameters: displacement in x point $P2$, and coefficient of piloting:.

Displacement at the point $P2$	Force applied at the point $P2$	*Reference*	*% difference*
1.00000E+00	-1.00000E+00	0.40541 E+03	1.7
2.00000E+00	-2.00000E+00	0.67551 E+03	5.7
3.00000E+00	-3.00000E+00	0.86633 E+03	5.9
4.00000E+00	-4.00000E+00	1.01265 E+03	5.3
5.00000E+00	-5.00000E+00	1.12588 E+03	4.7
6.00000E+00	-6.00000E+00	1.21543 E+03	4.2
7.00000E+00	-7.00000E+00	1.29151 E+03	4.5
8.00000E+00	-8.00000E+00	1.35855 E+03	3.6
9.00000E+00	-9.00000E+00	1.41888 E+03	3.0
1.00000E+01	-1.00000E+01	1.47379 E+03	2.5
1.10000E+01	-1.10000E+01	1.52345 E+03	2.5
1.20000E+01	-1.20000E+01	1.56775 E+03	1.9
1.30000E+01	-1.30000E+01	1.60583 E+03	1.2
1.40000E+01	-1.40000E+01	1.63667 E+03	0.6
1.50000E+01	-1.50000E+01	1.66105 E+03	-0.8



8Modeling F

8.1Characteristics of modeling

Simple support on the average line. Elastoplasticity of Von Mises with linear isotropic work hardening in great displacements.

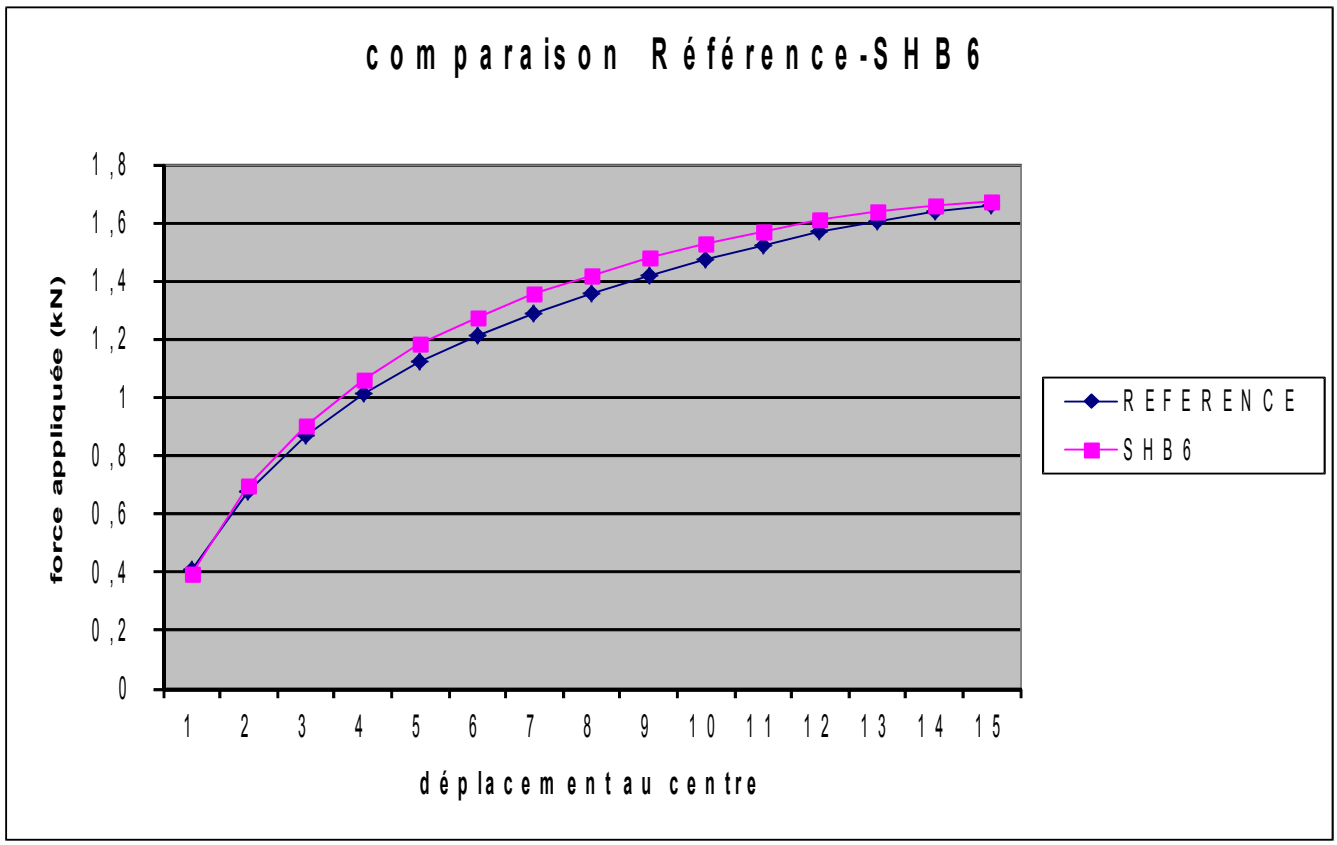
8.2Characteristics of the grid

Many nodes: 1922
Many meshs and types: 1800 SHB6.

8.3Sizes tested and results of modeling F

Identified parameters: displacement in x point $P2$, and coefficient of piloting:.

Displacement at the point $P2$	Force applied at the point $P2$	*Reference*	*% difference*
1.00000E+00	-1.00000E+00	0.40541 E+03	-2.0
2.00000E+00	-2.00000E+00	0.67551 E+03	2.8
3.00000E+00	-3.00000E+00	0.86633 E+03	4.4
4.00000E+00	-4.00000E+00	1.01265 E+03	4.8
5.00000E+00	-5.00000E+00	1.12588 E+03	5.0
6.00000E+00	-6.00000E+00	1.21543 E+03	5.1
7.00000E+00	-7.00000E+00	1.29151 E+03	4.9
8.00000E+00	-8.00000E+00	1.35855 E+03	4.6
9.00000E+00	-9.00000E+00	1.41888 E+03	4.3
1.00000E+01	-1.00000E+01	1.47379 E+03	3.8
1.10000E+01	-1.10000E+01	1.52345 E+03	3.3
1.20000E+01	-1.20000E+01	1.56775 E+03	2.6
1.30000E+01	-1.30000E+01	1.60583 E+03	2.0
1.40000E+01	-1.40000E+01	1.63667 E+03	1.4
1.50000E+01	-1.50000E+01	1.66105 E+03	0.8



9Modeling G

9.1Characteristics of modeling

Simple support on the average line. Elastoplasticity of Von Mises with linear isotropic work hardening in great displacements.

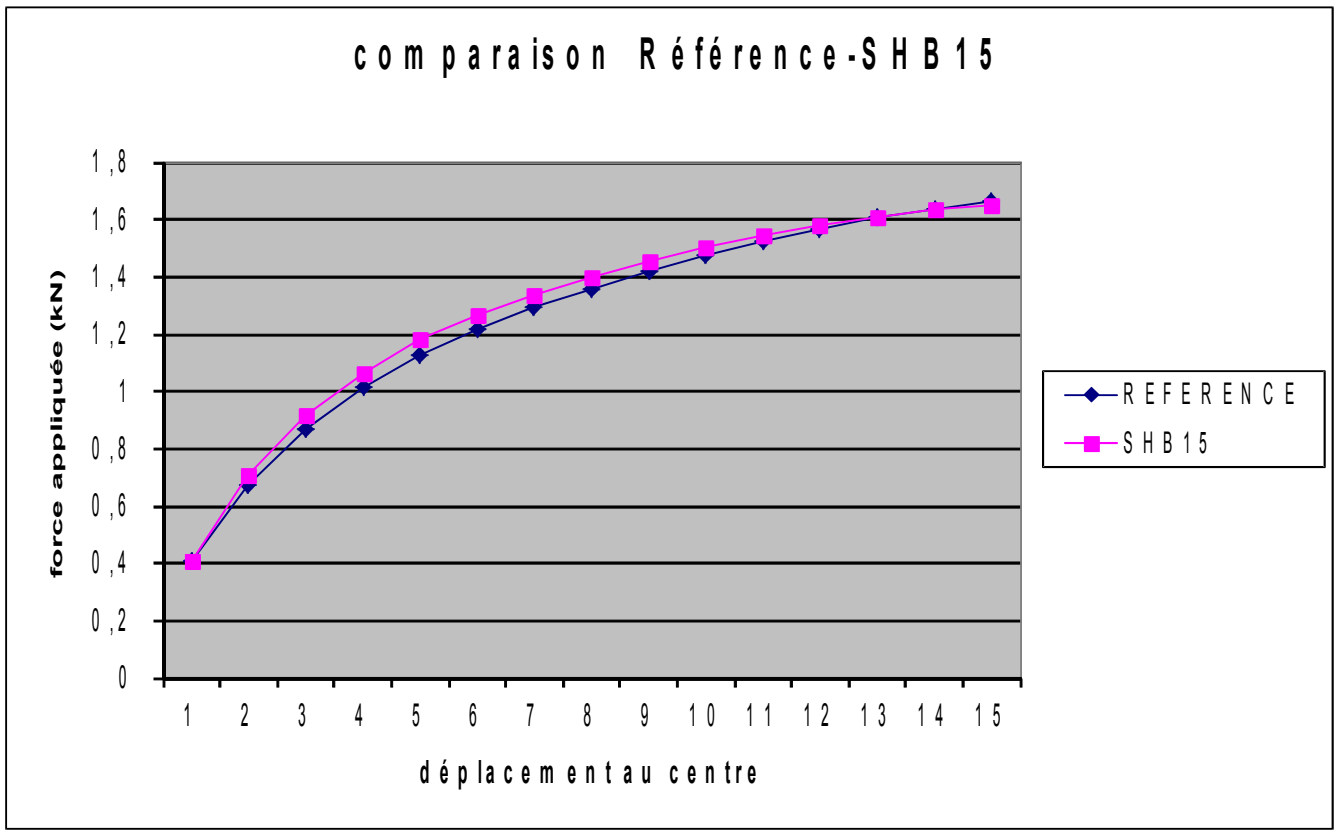
9.2Characteristics of the grid

Many nodes: 3803
Many meshs and types: 1800 SHB15.

9.3Sizes tested and results of modeling G

Identified parameters: displacement in x point $P2$, and coefficient of piloting:.

Displacement at the point $P2$	Force applied at the point $P2$	*Reference*	*% difference*
1.00000E+00	-1.00000E+00	0.40541 E+03	1.3
2.00000E+00	-2.00000E+00	0.67551 E+03	5.1
3.00000E+00	-3.00000E+00	0.86633 E+03	5.7
4.00000E+00	-4.00000E+00	1.01265 E+03	5.3
5.00000E+00	-5.00000E+00	1.12588 E+03	4.8
6.00000E+00	-6.00000E+00	1.21543 E+03	4.3
7.00000E+00	-7.00000E+00	1.29151 E+03	4.5
8.00000E+00	-8.00000E+00	1.35855 E+03	3.7
9.00000E+00	-9.00000E+00	1.41888 E+03	3.1
1.00000E+01	-1.00000E+01	1.47379 E+03	2.5
1.10000E+01	-1.10000E+01	1.52345 E+03	2.0
1.20000E+01	-1.20000E+01	1.56775 E+03	1.4
1.30000E+01	-1.30000E+01	1.60583 E+03	0.7
1.40000E+01	-1.40000E+01	1.63667 E+03	-0.2
1.50000E+01	-1.50000E+01	1.66105 E+03	-0.6



10Modeling H

10.1Characteristics of modeling

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

10.2Characteristics of the grid

Many nodes: 242
Many meshs and types: 100 HEXA8.

10.3Sizes tested and results of modeling C

Identified parameters: displacement in x point $P2$, and coefficient of piloting:.

Displacement at the point $P2$	Force applied at the point $P2$	*Reference*	*% difference*
1.00000E+00	-1.00000E+00	0.40541 E+03	2.8
2.00000E+00	-2.00000E+00	0.67551 E+03	6.0
3.00000E+00	-3.00000E+00	0.86633 E+03	6.5
4.00000E+00	-4.00000E+00	1.01265 E+03	6.5
5.00000E+00	-5.00000E+00	1.12588 E+03	5.5
6.00000E+00	-6.00000E+00	1.21543 E+03	5.0
7.00000E+00	-7.00000E+00	1.29151 E+03	4.5
8.00000E+00	-8.00000E+00	1.35855 E+03	4.0
9.00000E+00	-9.00000E+00	1.41888 E+03	3.5
1.00000E+01	-1.00000E+01	1.47379 E+03	3.0
1.10000E+01	-1.10000E+01	1.52345 E+03	2.5
1.20000E+01	-1.20000E+01	1.56775 E+03	2.0
1.30000E+01	-1.30000E+01	1.60583 E+03	1.6
1.40000E+01	-1.40000E+01	1.63667 E+03	1.4
1.50000E+01	-1.50000E+01	1.66105 E+03	1.1

The results are identical to those of modeling C, which was expected.

11Summary of the results

Results got by *Code_Aster* with modeling SHB show the capacity of all the elements of this modeling to deal with problems of thin hulls with nongeometrical and behavioral linearities.