

## SSNS109 – Cantilever beam subjected to Summarized

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### shears:

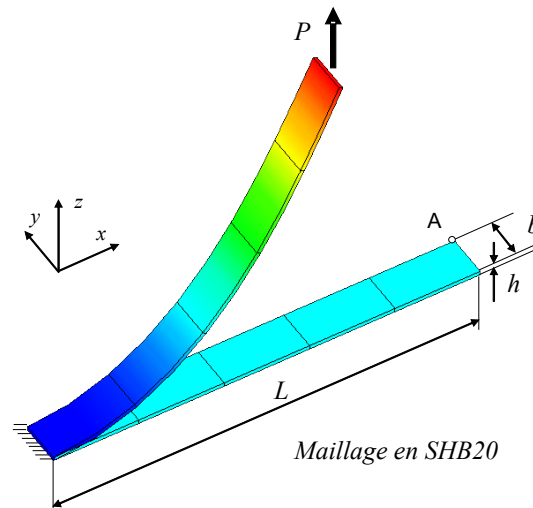
This test of nonlinear quasi-static mechanics makes it possible to validate elements SHB in nonlinear geometrical.

Four modelizations make it possible to study various configurations:

- modelization A with D: linear elastic behavior, large displacements, test on all the elements SHB (SHB8, SHB6, SHB20, SHB15)

## 1 Problem of reference

### 1.1 Geometry



Geometry, loading and displacement of the cantilever beam into nonlinear geometrical and large displacement, example of a mesh of 5 elements SHB20

- Dimensions of beam:
  - $L = 10\text{m}$
  - $b = 1$
  - Thickness  $h = 0.1\text{m}$

### 1.2 Properties of the material

the built-in characteristics are the following ones:

Elastic characteristics:

$$E = 1.2 \times 10^6 \text{ Pa}$$

$$NU = 0$$

### 1.3 Boundary conditions and loadings

the beam is embedded at an end. The other end is free and one applies a concentrated force  $P$  according to the direction  $Z$ . This force is applied incrementalement of 0 to  $P_{\max}$  :

$$P_0 = \frac{EI}{L^2} = 1 \text{ N} \text{ and } P_{\max} = 4 P_0$$

the loading formulates is controlled by the value of the following displacement  $Z$  of the point  $A$ . The amplitude of the force (coefficient  $\text{ETA}$  of control) is increased so that displacement grows until 6.7mm by step of 0.1mm.

## 2 Reference solution

### 2.1 numerical

Method of calculating Solution [bib1]: values of the parameter of control (thus of the force  $P$ ) according to time (thus of the displacement  $U_z$  of the point  $A$ ).

### 2.2 Quantities and results of reference

Coefficient of control (Multiplying coefficient of the applied force) according to the displacement  $U_z$  of the point  $A$ .

Results of reference got by a modelization in 16x1x1 elements shell  $S4R$  of Abaqus.

$P/P_{max}$	$-U_x(m)$	$U_z(m)$	$P/P_{max}$	$-U_x(m)$	$U_z(m)$	$P/P_{max}$	$-U_x(m)$	$U_z(m)$
0.05	0,026	0,663	0,4	1,184	4,292	0,75	2,541	6,031
0.1	0,103	1,309	0,45	1,396	4,631	0,8	2,705	6,190
0.15	0,224	1,922	0,5	1,604	4,933	0,85	2,861	6,335
0.2	0,381	2,493	0,55	1,807	5,202	0,9	3,01	6,467
0.25	0,563	3,015	0,6	2,002	5,444	0,95	3,151	6,588
0.3	0,763	3,488	0,65	2,190	5,660	1	3,286	6,698
0.35	0,971	3,912	0,7	2,370	5,855			

### 2.3 Uncertainties on the solution

Without object

### 2.4 bibliographical References

1.Sze K.Y, Liu X.H, and Lo S.H. Popular benchmark problems for geometric nonlinear analysis of shells. *Finite Elements in Analysis and Design*, Volume 40, Issue 11, Pages 1551-156, 2004.

## 3 Modelization A

### 3.1 Characteristic of the modelization

Fixed support of an end. Linear elasticity in large displacements.

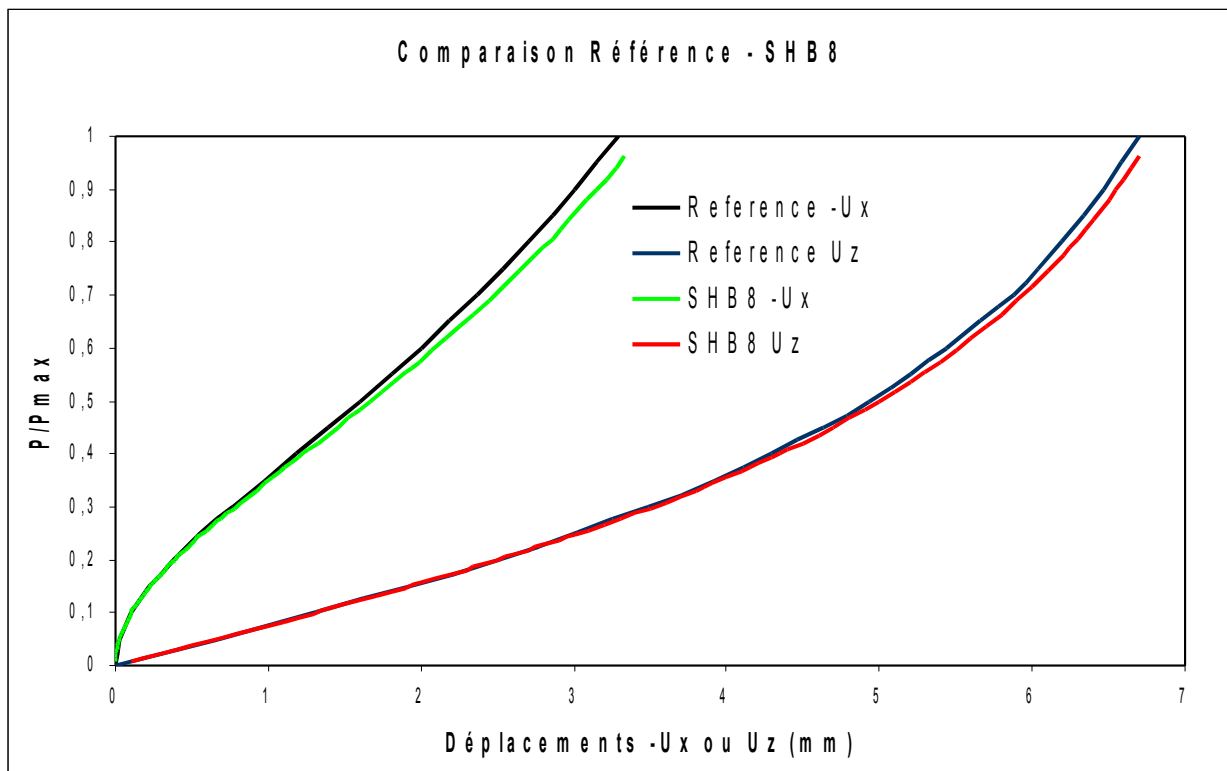
### 3.2 Characteristics of the mesh

Many nodes: 126  
Number of meshes and types: 40 HEXA8 .

### 3.3 Quantities tested and identified

Parameters results: coefficient of control (applied force), displacement in  $x$  and  $z$  of point:  $A$

Reference			Code_Aster			% difference	
$P/P_{max}$	$-U_x(m)$	$U_z(m)$	$P/P_{max}$	$-U_x(m)$	$U_z(m)$	$-U_x(m)$	$P/P_{max}$
0,00	0,00	0,000	0,008	0,000	0,000	0,0	0
0,05	0,026	0,663	0,050	0,026	0,663	0,0.0,1	
0,10	0,103	1,309	0,100	0,110	1,309	1,9.0,2	
0,15	0,224	1,922	0,149	0,222	1,922	0,9.0,5	
0,20	0,381	2,493	0,199	0,387	2,493	-1,6	0,7
0,25	0,563	3,015	0,247	0,563	3,015	0,0.1.0	
0,30	0,763	3,488	0,296	0,775	3,488	-1,6	1,3
0,35	0,971	3,912	0,344	0,973	3,912	-0,2	1,6
0,40	1,184	4,292	0,392	1,199	4,292	-1,3	1,9
0,45	1,396	4,631	0,440	1,405	4,631	-0,6	2,1
0,50	1,604	4,933	0,488	1,595	4,933	0,6.2,4	
0,55	1,807	5,202	0,535	1,810	5,202	-0,2	2,7
0,60	2,002	5,444	0,583	1,995	5,444	0,3.2,8	
0,65	2,19	5,660	0,630	2,210	5,660	-0,9	3,1
0,70	2,37	5,885	0,685	2,400	5,885	-1,3	2,1
0,75	2,541	6,031	0,725	2,543	6,031	-0,1	3,4
0,80	2,705	6,190	0,772	2,709	6,190	-0,1	3,5
0,85	2,861	6,335	0,819	2,859	6,335	0,1.3,6	
0,90	3,01	6,467	0,866	3,070	6,467	-2,0	3,7
0,95	3,151	6,588	0,914	3,192	6,588	-1,3	3,8
1,00	3,286	6,698	0,961	3,301	6,698	-0,5	3,9



## 4 Modelization B

### 4.1 Characteristic of the modelization

Fixed support of an end. Linear elasticity in large displacements.

### 4.2 Characteristics of the mesh

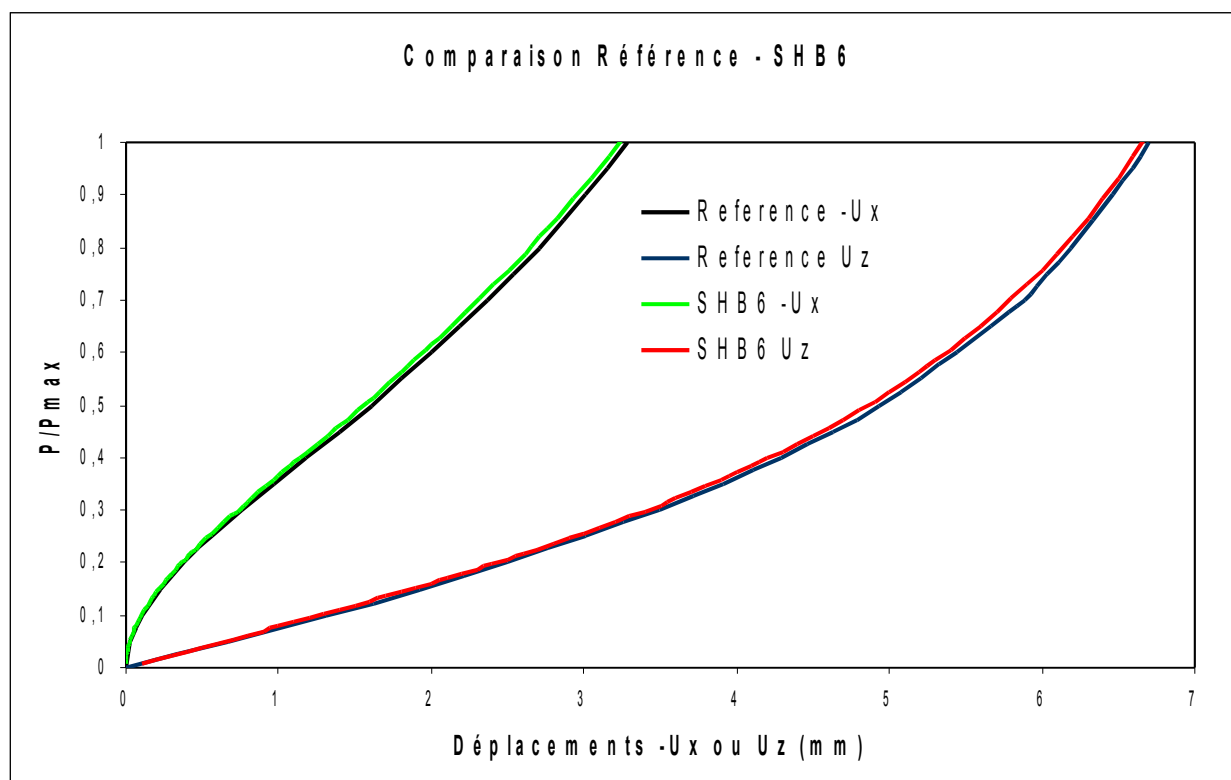
Many nodes: 2222

Number of meshes and types: 2000 PENTA6 .

### 4.3 Quantities tested and results of the modelization B

identified Parameters: coefficient of control (applied force), displacement in  $x$  and  $z$  of point:  $A$

Reference			Code_Aster			% difference	
$P/P_{max}$	$-U_x(m)$	$U_z(m)$	$P/P_{max}$	$-U_x(m)$	$U_z(m)$	$-U_x(m)$	$P/P_{max}$
0,00	0,00	0,000	0,008	0,001	0,000	0,0	0
0,05	0,026	0,663	0,051	0,026	0,663	0,00	-2,00
0,10	0,103	1,309	0,103	0,104	1,309	-0,97	-3,00
0,15	0,224	1,922	0,154	0,222	1,922	0,89	-2,67
0,20	0,381	2,493	0,206	0,387	2,493	-1,57	-3,00
0,25	0,563	3,015	0,257	0,561	3,015	0,36	-2,80
0,30	0,763	3,488	0,308	0,750	3,488	1,70	-2,67
0,35	0,971	3,912	0,359	0,970	3,912	0,10	-2,57
0,40	1,184	4,292	0,410	1,153	4,292	2,62	-2,50
0,45	1,396	4,631	0,462	1,380	4,631	1,15	-2,67
0,50	1,604	4,933	0,513	1,585	4,933	1,18	-2,60
0,55	1,807	5,202	0,564	1,808	5,202	-0,06	-2,55
0,60	2,002	5,444	0,615	1,968	5,444	1,70	-2,50
0,65	2,19	5,660	0,666	2,138	5,660	2,37	-2,46
0,70	2,37	5,885	0,725	2,319	5,885	2,15	-3,57
0,75	2,541	6,031	0,767	2,510	6,031	1,22	-2,27
0,80	2,705	6,190	0,818	2,714	6,190	-0,33	-2,25
0,85	2,861	6,335	0,868	2,820	6,335	1,43	-2,12
0,90	3,01	6,467	0,919	2,990	6,467	0,66	-2,11
0,95	3,151	6,588	0,969	3,160	6,588	-0,29	-2,00
1,00	3,286	6,698	1,019	3,281	6,698	0,15	-1,90



## 5 Modelization C

### 5.1 Characteristic of the modelization

Fixed support of an end. Linear elasticity in large displacements.

### 5.2 Characteristics of the mesh

Many nodes: 68

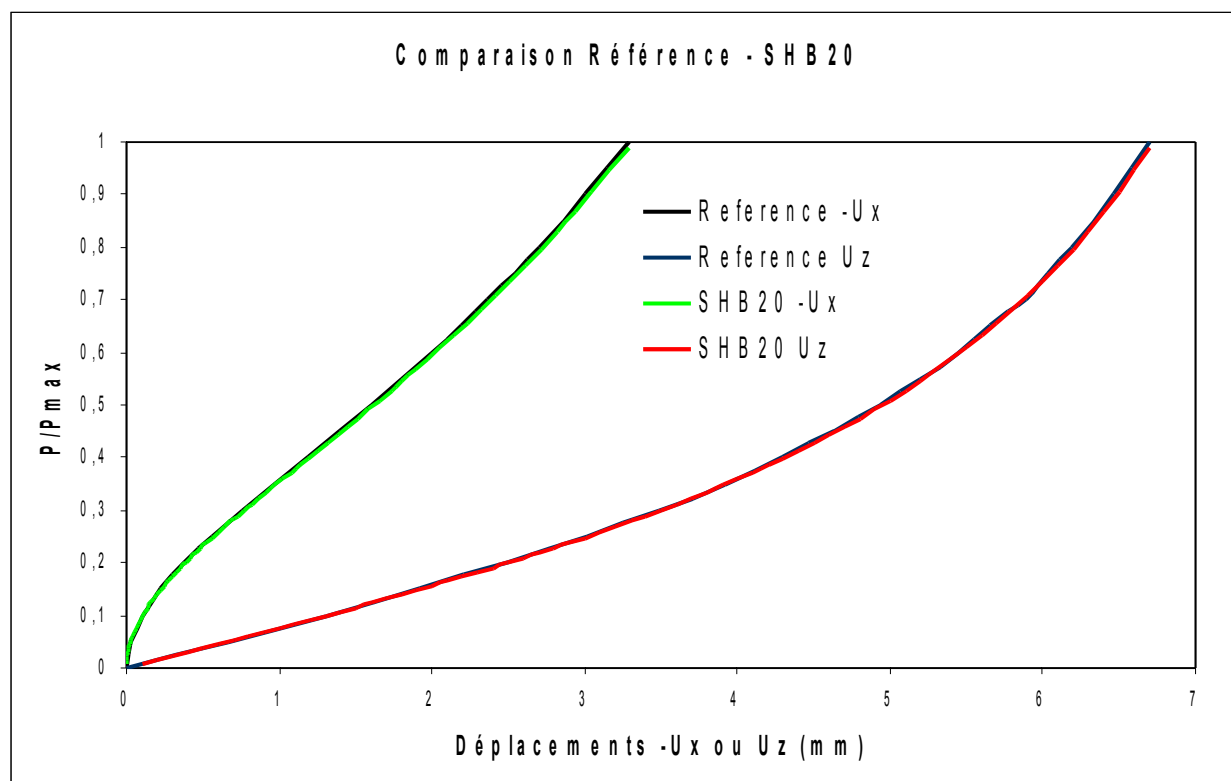
Number of meshes and types: 5 HEXA20.

### 5.3 Quantities tested and results of the modelization C

identified Parameters: coefficient of control (applied force), displacement in  $x$  and  $z$  of point:  $A$

Reference			Aster			% difference	
$P/P_{max}$	$-U_x(m)$	$U_z(m)$	$P/P_{max}$	$-U_x(m)$	$U_z(m)$	$-U_x(m)$	$P/P_{max}$
0,00	0,00	0,000	0,008	0,001	0,000	0,00	2,00
0,05	0,026	0,663	0,049	0,026	0,663	-0,97	1,00
0,10	0,103	1,309	0,099	0,104	1,309	0,89	0,67
0,15	0,224	1,922	0,149	0,222	1,922	-1,57	0,50
0,20	0,381	2,493	0,199	0,387	2,493	0,36	0,40
0,25	0,563	3,015	0,249	0,561	3,015	0,39	0,33
0,30	0,763	3,488	0,299	0,760	3,488	0,10	0,57
0,35	0,971	3,912	0,348	0,970	3,912	0,93	0,50
0,40	1,184	4,292	0,398	1,173	4,292	0,43	0,44
0,45	1,396	4,631	0,448	1,390	4,631	0,56	0,60
0,50	1,604	4,933	0,497	1,595	4,933	-0,06	0,55
0,55	1,807	5,202	0,547	1,808	5,202	-0,05	0,67
0,60	2,002	5,444	0,596	2,003	5,444	0,37	0,77
0,65	2,19	5,660	0,645	2,182	5,660	-1,69	-0,43
0,70	2,37	5,885	0,703	2,410	5,885	0,43	0,80
0,75	2,541	6,031	0,744	2,530	6,031	-0,26	0,88
0,80	2,705	6,190	0,793	2,712	6,190	0,28	0,94
0,85	2,861	6,335	0,842	2,853	6,335	-0,37	1,00
0,90	3,01	6,467	0,891	3,021	6,467	0,03	1,05
0,95	3,151	6,588	0,940	3,150	6,588	0,06	1,10
1,00	3,286	6,698	0,989	3,284	6,698	0,00	2,00





## 6 Modelization D

### 6.1 Characteristic of the modelization

Fixed support of an end. Linear elasticity in large displacements.

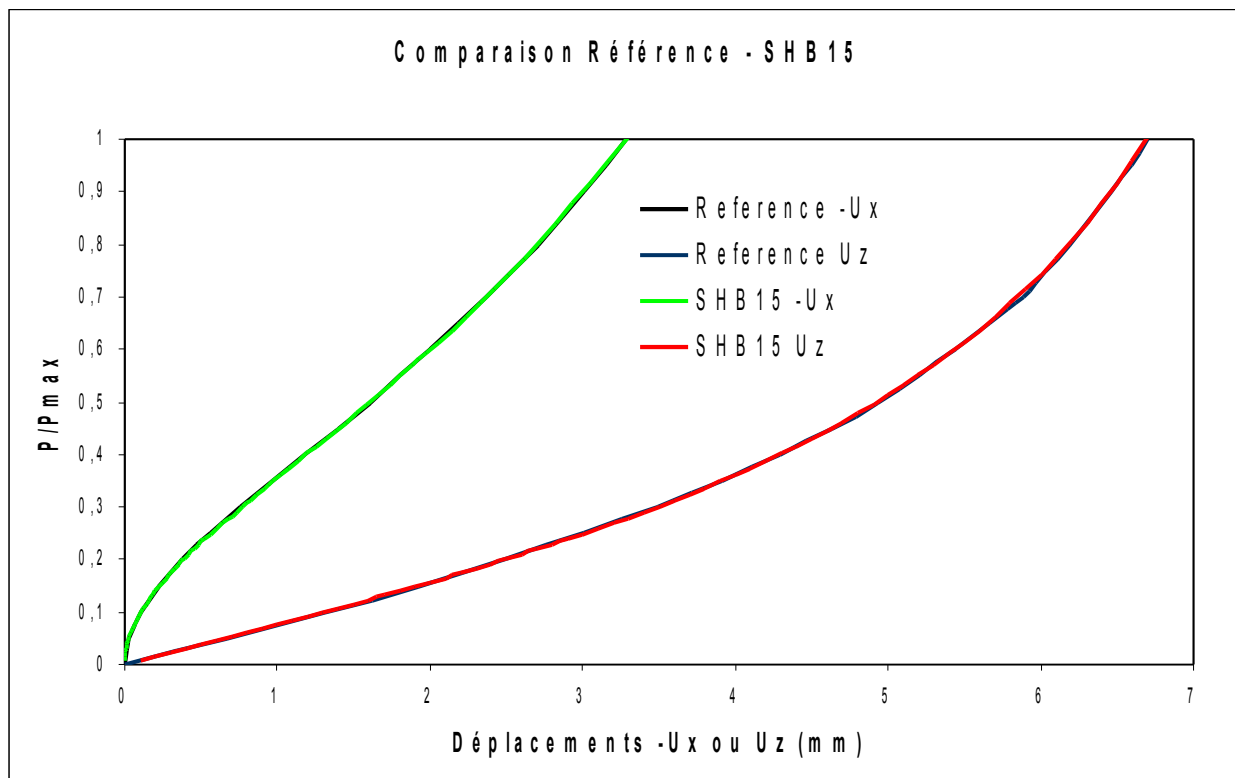
### 6.2 Characteristics of the mesh

Many nodes: 218  
Number of meshes and types: 30 PENTA15.

### 6.3 Quantities tested and results of the modelization D

identified Parameters: coefficient of control (applied force), displacement in  $x$  and  $z$  of point:  $A$

Reference			Aster			% difference	
$P/P_{max}$	$-U_x(m)$	$U_z(m)$	$P/P_{max}$	$-U_x(m)$	$U_z(m)$	$-U_x(m)$	$P/P_{max}$
0,00	0,00	0,000	0,008	0,001	0,000	0,00	2,00
0,05	0,026	0,663	0,049	0,026	0,663	-1,94	1,00
0,10	0,103	1,309	0,099	0,105	1,309	0,45	0,67
0,15	0,224	1,922	0,149	0,223	1,922	-0,26	0,50
0,20	0,381	2,493	0,199	0,382	2,493	-5,86	0,40
0,25	0,563	3,015	0,249	0,596	3,015	0,26	0,33
0,30	0,763	3,488	0,299	0,761	3,488	0,10	0,29
0,35	0,971	3,912	0,349	0,970	3,912	0,34	0,00
0,40	1,184	4,292	0,400	1,180	4,292	0,29	0,00
0,45	1,396	4,631	0,450	1,392	4,631	0,87	0,00
0,50	1,604	4,933	0,500	1,590	4,933	0,28	0,00
0,55	1,807	5,202	0,550	1,802	5,202	0,10	-0,17
0,60	2,002	5,444	0,601	2,000	5,444	0,46	-0,15
0,65	2,19	5,660	0,651	2,180	5,660	-0,84	-1,43
0,70	2,37	5,885	0,710	2,390	5,885	0,04	-0,27
0,75	2,541	6,031	0,752	2,540	6,031	-0,22	-0,25
0,80	2,705	6,190	0,802	2,711	6,190	-0,07	-0,24
0,85	2,861	6,335	0,852	2,863	6,335	-0,03	-0,33
0,90	3,01	6,467	0,903	3,011	6,467	-0,03	-0,32
0,95	3,151	6,588	0,953	3,152	6,588	-0,12	-0,30
1,00	3,286	6,698	1,003	3,290	6,698	0,00	2,00



## 7 Summary of the results

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the results got by *Code\_Aster* with modelization `SHB` show the capacity of all the elements of this modelization to dealing with problems with geometric nonlinearities.