SSNS109 – Beam comforts subjected to a shearing action

Summary:

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

Four modelings make it possible to study various configurations:

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

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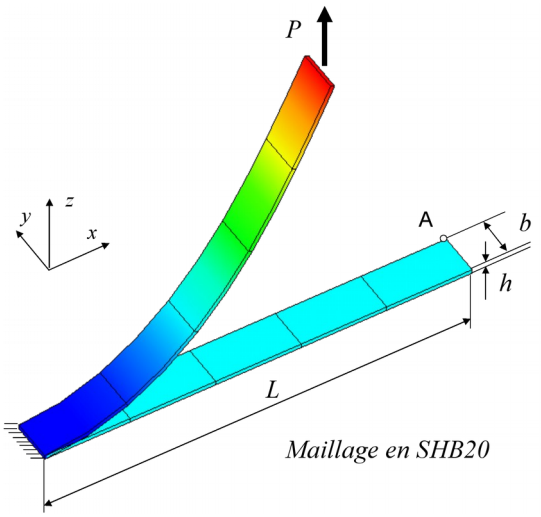
1 Problem of reference

1.1 Geometry



Geometry, loading and displacement of the beam comfort into non-linear geometrical and great displacement, example of a grid of 5 elements SHB20

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

1.2 Properties of material

The fixed characteristics are the following ones:

Elastic characteristics:

$$E=1.2\text{x}106\ Pa$$
$$NU=0$$

1.3 Boundary conditions and loadings

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

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

The loading is controlled by the value of following displacement Z point A. The amplitude of the force (coefficient ETA by piloting) is increased so that displacement grows until 6.7mm by step of 0.1mm.

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2 Reference solution

2.1 Method of calculating

Digital solution [bib1]: values of the parameter of piloting (thus of the force P) according to the time (thus of displacement Uz point A).

2.2 Sizes and results of reference

Coefficient of piloting (Multiplying coefficient of the force applied) according to displacement Uz point A.

Results of reference got by a modeling in 16x1x1 elements hull $S4R$ 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.

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3 Modeling A

3.1 Characteristics of modeling

Embedding of an end. Linear elasticity in great displacements.

3.2 Characteristics of the grid

Many nodes: 126
Many meshs and types: 40 HEXA8 .

3.3 Sizes tested and results

Identified parameters: coefficient of piloting (force applied), displacement in x and z 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

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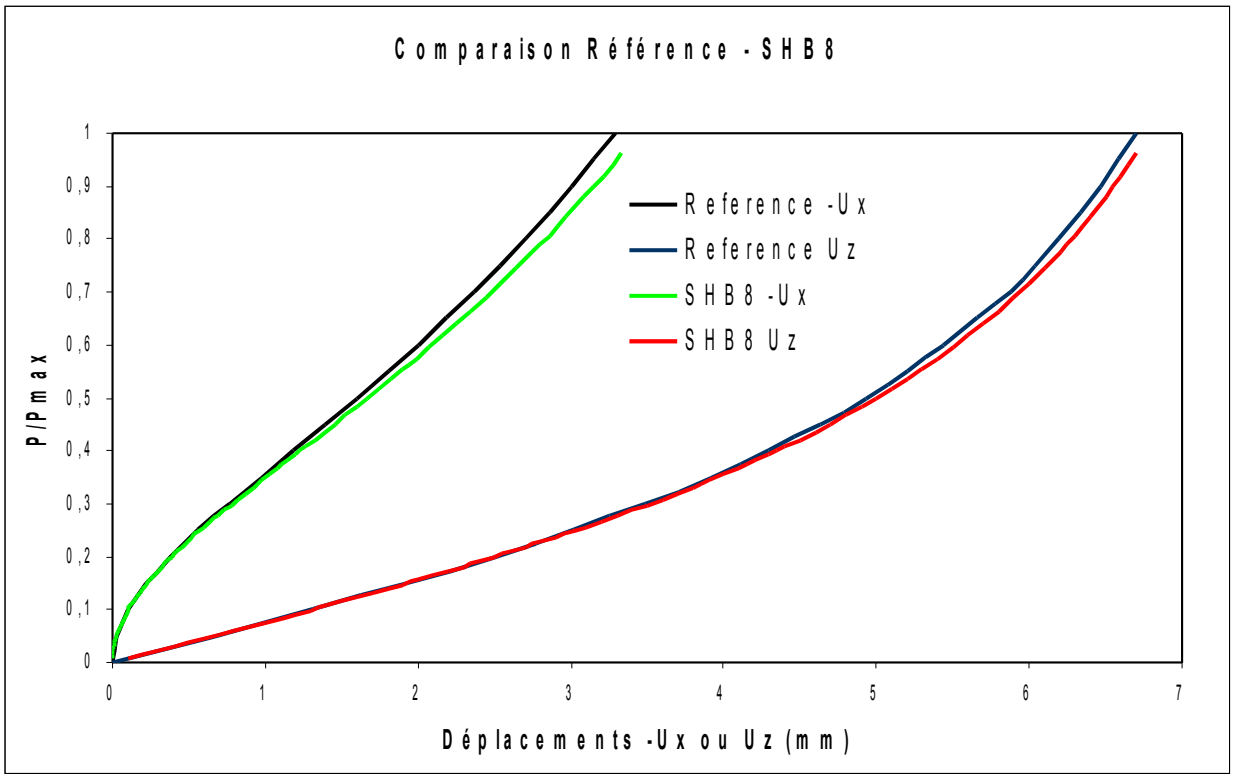

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4 Modeling B

4.1 Characteristics of modeling

Embedding of an end. Linear elasticity in great displacements.

4.2 Characteristics of the grid

Many nodes: 2222
Many meshs and types: 2000 PENTA6 .

4.3 Sizes tested and results of modeling B

Identified parameters: coefficient of piloting (force applied), displacement in x and z 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

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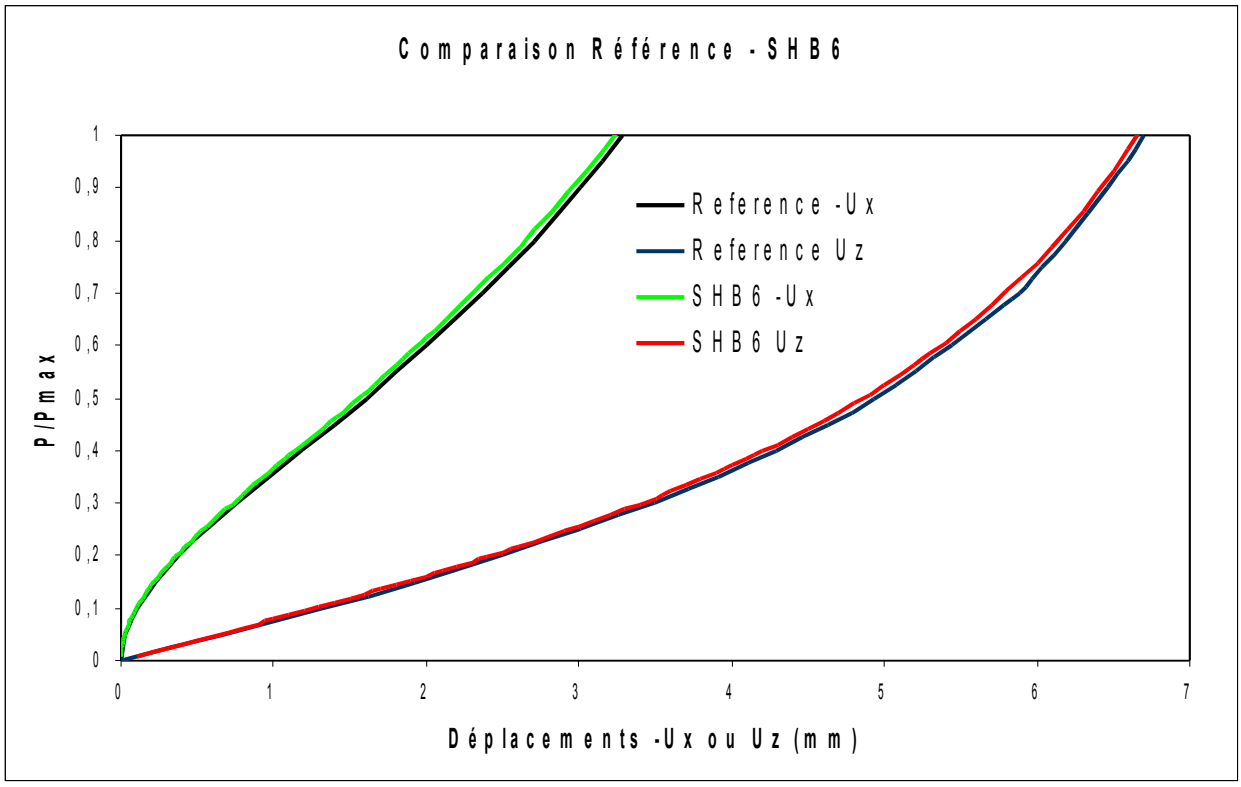

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5 Modeling C

5.1 Characteristics of modeling

Embedding of an end. Linear elasticity in great displacements.

5.2 Characteristics of the grid

Many nodes: 68
Many meshs and types: 5 HEXA20.

5.3 Sizes tested and results of modeling C

Identified parameters: coefficient of piloting (force applied), displacement in x and z 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

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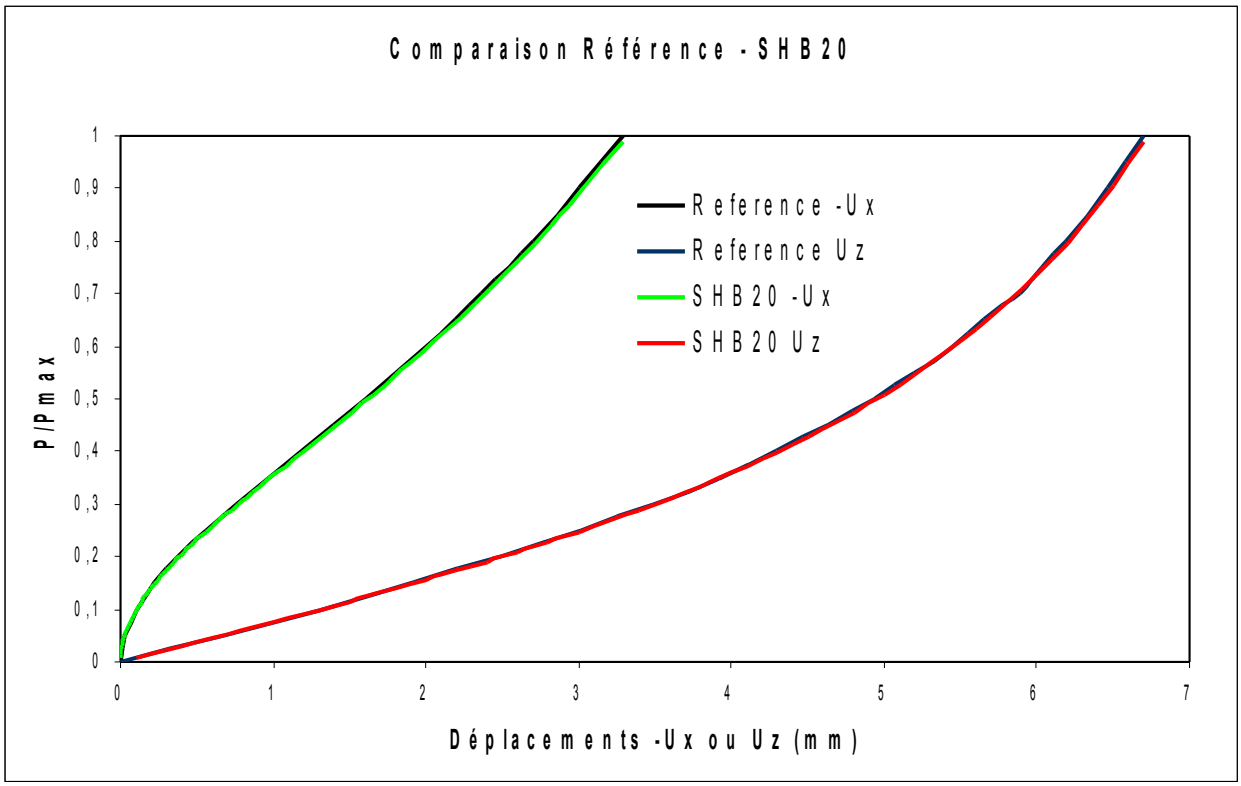

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6 Modeling D

6.1 Characteristics of modeling

Embedding of an end. Linear elasticity in great displacements.

6.2 Characteristics of the grid

Many nodes: 218
Many meshs and types: 30 PENTA15.

6.3 Sizes tested and results of modeling D

Identified parameters: coefficient of piloting (force applied), displacement in x and z 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

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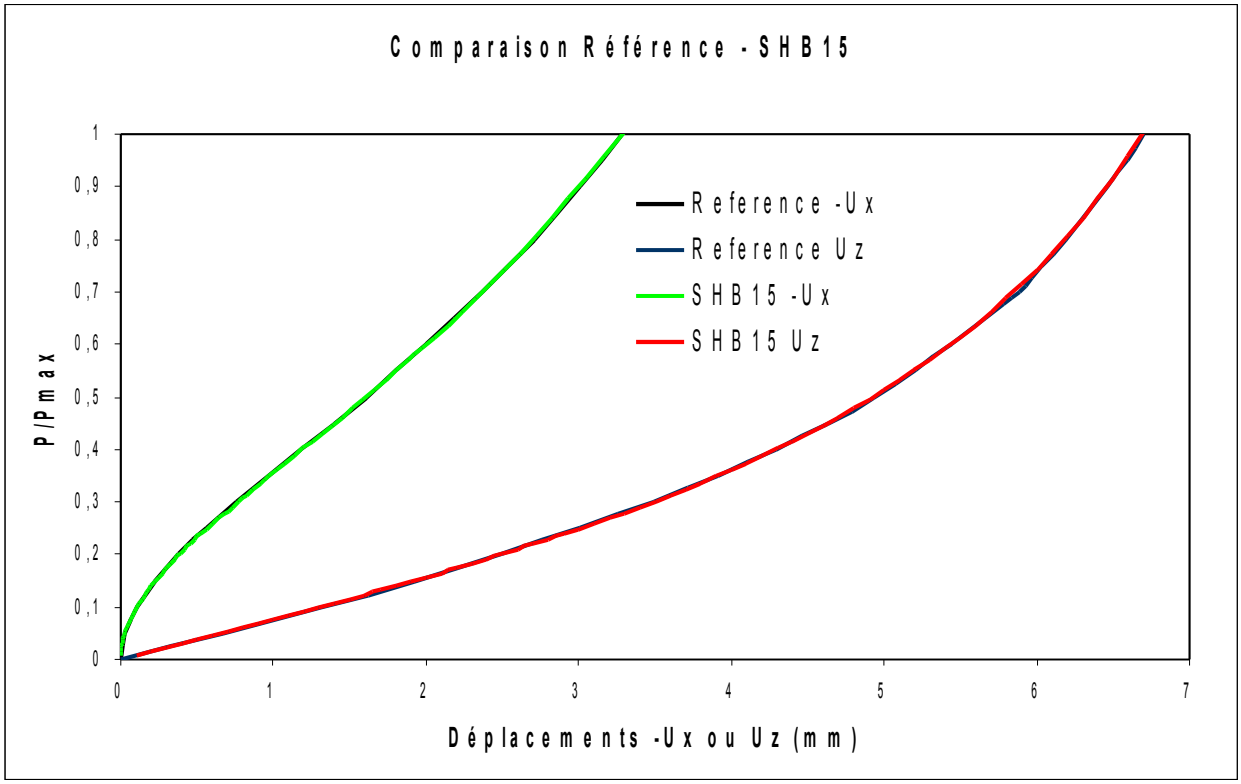

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7 Summary of the results

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

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