SSLS123 - Sphere under external pressure uniform

Abstract:

One treats the case of the sphere under uniform pressure external in linear elasticity, which makes it possible to evaluate the quality of the modelization of the compressive forces.

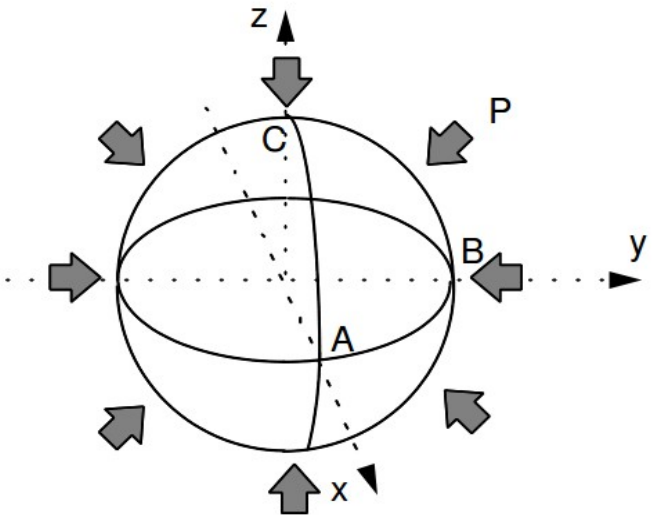
The values tested are radial displacements at the points of intersection with the axes.

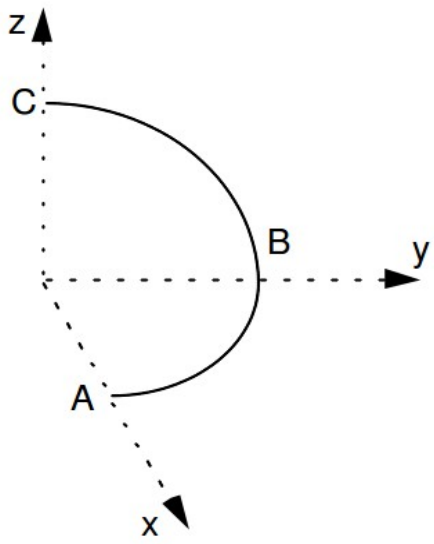
One has 2 modelizations:

- A: elements 3D in HEXA8
- b: elements SHB8

1 Problem of reference

1.1 Geometry





Radius	$R=10\text{m}$
Thickness	$t=0.04\text{m}$

Coordinated points:

	A	B	C
x	10.	0.	0.
y	0.	10.	0.
z	0.	0.	10.

1.2 Material properties

$E=6.825\,10^{7}\ Pa$
$\nu=0.3$

1.3 Boundary conditions and loadings

On a quarter of the hemisphere:

Side AC symmetry compared to the plane xz
Side BC symmetry compared to the plane yz
Side AB symmetry compared to the external xy

Pressure plane uniform $P=1.\text{Pa}$

2 Reference solution

2.1 Method of calculating used for the reference solution

radial displacement in any node of the sphere under external pressure is given by:

$$U_r = B \cdot r + \frac{C}{r^2}$$

With

$$B = \frac{1-2\nu}{E} \cdot \frac{r_e^3}{r_i^3 - r_e^3} \cdot P \quad \text{and} \quad C = \frac{1+\nu}{2E} \cdot \frac{r_i^3 r_e^3}{r_i^3 - r_e^3} \cdot P$$

where $r_i = R - \frac{t}{2}$ and $r_e = R + \frac{t}{2}$

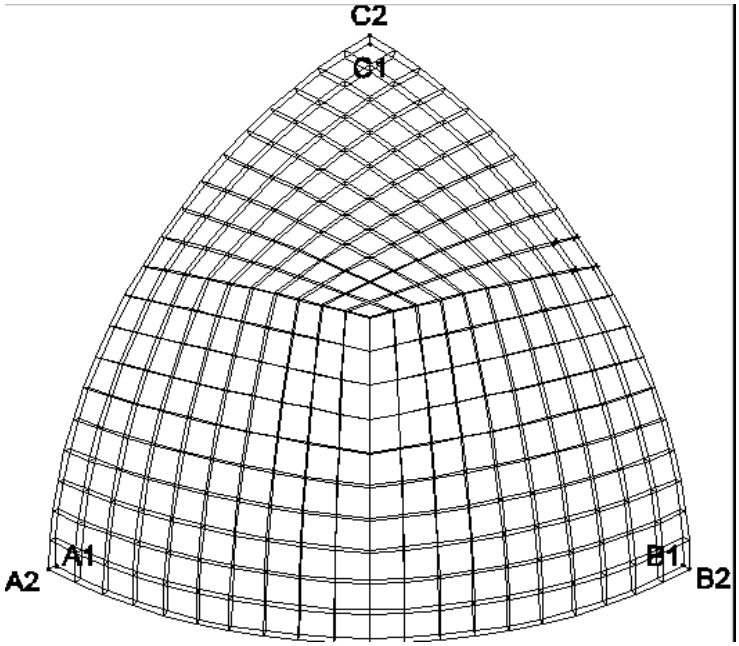
2.2 Results of reference

Displacement of the following A point x, displacement of the following B point y, displacement of the following C point z.

3 Modelization A

3.1 Characteristic of the modelization

Shell element SHB



Modelization of a quarter of the sphere in SHB

Names of the nodes:

Not *A1*	*N40*	Not *A2*	*N42*
Not *B1*	*N01*	Not *B2*	*N02*
Not *C1*	*N662*	Not *C2*	*N658*

3.2 Characteristic of the mesh

Many nodes: 662
Number of meshes and types: 300 SHB for the sphere and 300 QUAD4 for external surface.

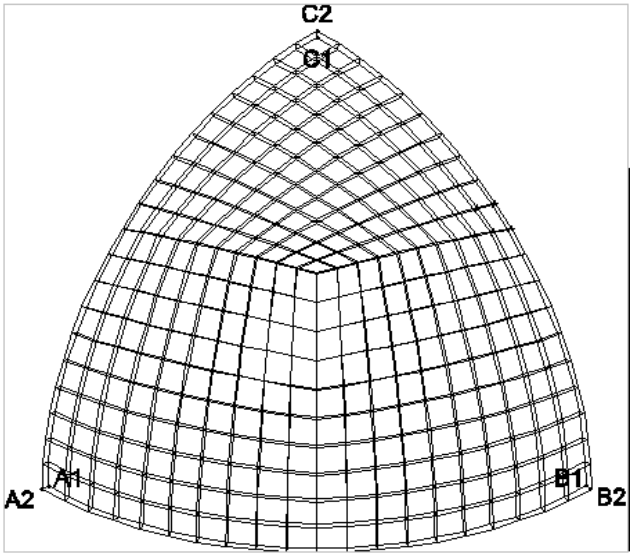
3.3 Values tested and results of the modelization A

Identification	Reference	*Aster*	% difference
Not *A2* displacement *u*	– 1.28279.10-5	– 1.27928.10-5	0.27
Point *B2* displacement *v*	– 1.28279.10-5	– 1.27929.10-5	0.27
Point *C2* displacement *w*	– 1.28279.10-5	– 1.3034.10-5	1.7

4 Modelization B

4.1 Characteristic of the voluminal

modelization Element 3D HEXA8



Modelization of a quarter of the sphere in HEXA8.

Names of the nodes:

Not *A1*	*N40*	Not *A2*	*N42*
Not *B1*	*N01*	Not *B2*	*N02*
Not *C1*	*N662*	Not *C2*	*N658*

4.2 Characteristic of the mesh

Many nodes: 662
Number of meshes and types: 300 HEXA8 for the sphere and 300 QUAD4 for external surface.

4.3 Values tested and results of the modelization B

Identification	Reference	*Aster*	% difference
Not *A2* displacement *u*	– 1.28279.10-5	– 1.28298.10-5	0.015
Point *B2* displacement *v*	– 1.28279.10-5	– 1.28298.10-5	0.015
Point *C2* displacement *w*	– 1.28279.10-5	– 1.28662.10-5	0.30

5 Summary of the results

the results are in conformity with the reference solution.

One could expect to find exactly same displacement at the three points A, B and C. The difference at the point C comes from NON-symmetry from the mesh. The mesh is slightly more distorted around this point, which explains the fall of accuracy, which remains nevertheless very good, as well for element HEXA8 as for the SHB8.