SSLS09 - Thin cylinder under actual weight

Summary:

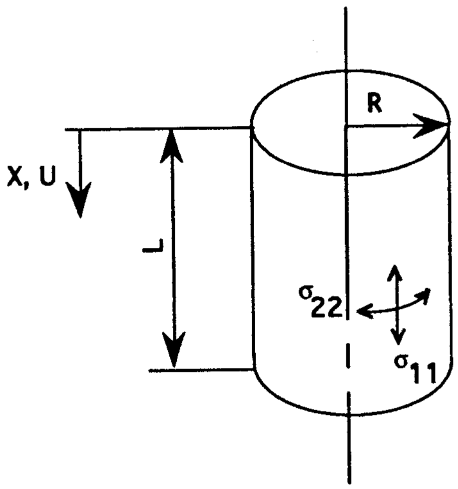
This test from guide VPCS (SSLS 09/89) aims to test a voluminal loading (here the actual weight), in axisymmetric analysis, by using the keyword FORCE_INTERNE.

One will use for that the two orders: AFFE_CHAR_MECA (modeling A) and AFFE_CHAR_MECA_F (modeling B).

Modeling C tests the incompressible elements by using the keyword GRAVITY on a loading are equivalent.

1 Problem of reference

1.1 Geometry



Average radius	:	$R=1\text{m}$
Thickness	:	$h=0.02\,m$
Height	:	$L=4\,m$

1.2 Material properties

Young modulus	:	$E=2.1\times 10^{11}\,Pa$
Poisson's ratio	:	$\nu=0.3$
Voluminal weight	:	$\gamma=7.85\times 10^{4}\,N/m^{3}$

1.3 Boundary conditions and loadings

- Axial displacement no one at the low end ($u=0$) + conditions of symmetry
- Actual weight, according to the axis, direction $+x$

2 Reference solution

2.1 Method of calculating used for the reference solution

In a point of coordinate X:

1) radial displacement: $U_r = -\frac{\gamma R \nu x}{E}$
2) axial displacement: $U_x = \frac{\gamma x^2}{2E}$
3) rotation of a generator: $\psi = -\frac{\gamma R \nu}{E}$
4) axial stress: $\sigma_{11} = \gamma x$
5) circumferential constraint: $\sigma_{22} = 0$

2.2 Results of reference

1) Axial displacement high end: $U_x = 2.99 \times 10^{-6} m$
2) Radial displacement low end: $U_r = -4.49 \times 10^{-7} m$
3) $\psi = -1.12 \times 10^{-7} rad$
4) $\sigma_{11} = 3.14 \times 10^5 Pa$, at the low end
5) $\sigma_{22} = 0$ everywhere

2.3 Uncertainty on the solution

Analytical solution.

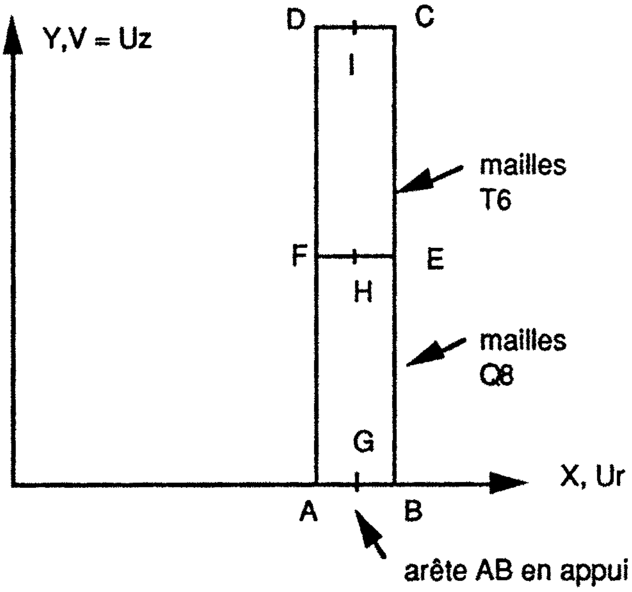
2.4 Bibliographical reference

- Guide VPCS – Edition 1990 (SSLS 09/89)
- R.J. ROARK and W.C. YOUNG: Formulated for stress and strain, 5 ème edition, New York, Mc Graw-Hill, 1975

3 Modeling A

3.1 Characteristics of modeling

AXIS, T6 meshs and Q8



Position of the points:

- E, F with middle height
- G, H, I remotely R axis

Cutting: 100 elements according to the height
1 element in the thickness

Limiting conditions: $DY=0$ on AB

Loading: Constant voluminal force equalizes with – 78500.

Name of the nodes:

Not $A=N1$	Not $C=N452$	Not $E=N201$	Not $G=N51$	Not $I=N503$
Not $B=N101$	Not $D=N504$	Not $F=N203$	Not $H=N202$	

3.2 Characteristics of the grid

Many nodes: 553
Many meshs and types: 50 QUAD8, 100 TRIA6, 204 SEG3

3.3 Values tested

Localization	Type of value	Reference
Points C, D, I	$u_x(m)$	$2.99 \ 10^{-6}$
Not G	$u_r(m)$	$-4.49 \ 10^{-7}$
Not G	$\sigma_{11}(Pa)$	$-3.14 \ 10^{5}$

Points A, B, G	$\sigma_{22}(Pa)$	0.

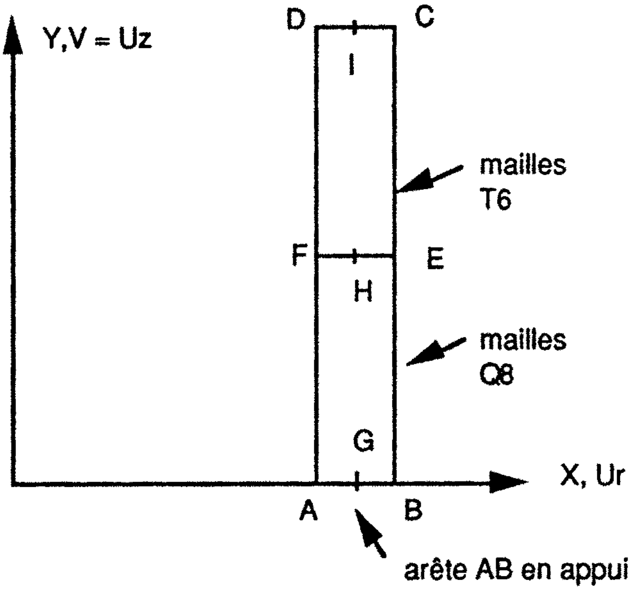
3.4 Remarks

1) Values of σ_{22} data are not significant.
2) Taking into account the grid (1 element in the thickness), the results are completely satisfactory.

4 Modeling B

4.1 Characteristics of modeling

AXIS, T6 meshs and Q8



Position of the points:

- E, F with middle height
- G, H, I remotely R axis

Cutting: 100 elements according to the height
1 element in the thickness

Limiting conditions: $DY=0$ on AB

Loading: Voluminal force in the form of a constant function defined in $y=0,3,6$.

Name of the nodes:

Not $A=N1$	Not $C=N452$	Not $E=N201$	Not $G=N51$	Not $I=N503$
Not $B=N101$	Not $D=N504$	Not $F=N203$	Not $H=N202$	

4.2 Characteristics of the grid

Many nodes: 553
Many meshs and types: 50 QUAD8, 100 TRIA6, 204 SEG3

4.3 Values tested

Localization	Type of value	Reference
Points C, D, I	$u_x(m)$	$2.99\ 10^{-6}$
Not G	$u_r(m)$	$-4.49\ 10^{-7}$
Not G	$\sigma_{11}(Pa)$	$-3.14\ 10^{5}$

Points A, B, G	$\sigma_{22}(Pa)$	0.

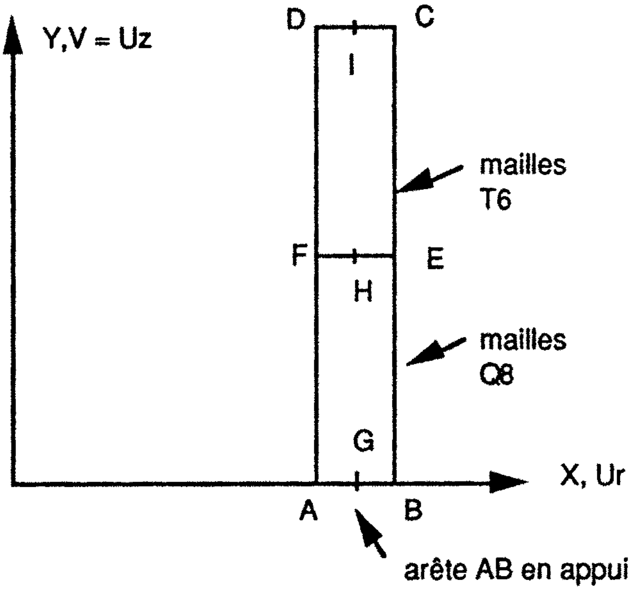
4.4 Remarks

1) Values of σ_{22} data are not significant.
2) The results are identical to those of modeling A.

5 Modeling C

5.1 Characteristics of modeling

`AXIS_INCO_UPG`, T6 meshs and Q8



Position of the points:

- E, F with middle height
- G, H, I remotely R axis

Cutting:	100 elements according to the height 1 element in the thickness
Limiting conditions:	$DY=0$ on AB
Loading:	Gravity

Name of the nodes:

Not $A=N1$	Not $C=N452$	Not $E=N201$	Not $G=N51$	Not $I=N503$
Not $B=N101$	Not $D=N504$	Not $F=N203$	Not $H=N202$	

5.2 Characteristics of the grid

Many nodes: 553
Many meshs and types: 50 QUAD8, 100 TRIA6, 204 SEG3

5.3 Values tested

Localization	Type of value	Reference
Points C, D, I	$u_x(m)$	$2.99\ 10^{-6}$
Not G	$u_r(m)$	$-4.49\ 10^{-7}$
Not G	$\sigma_{11}(Pa)$	$-3.14\ 10^{5}$
Points A, B, G	$\sigma_{22}(Pa)$	0.

5.4 Remarks

1) Values of σ_{22} found are not significant.
2) The results are identical to those of modeling A and B.

6 Summary of the results

The use of a function for the definition of a constant density of volume charge is valid: the results are identical, whether one uses one or the other of the 2 orders AFFE_CHAR_MECA or AFFE_CHAR_MECA_F. An equivalent loading gravity gives the same results.
Moreover, the incompressible elements give the same results (modeling C).