SHLV100 - Harmonic answer of a hollow roll in plane deformations

Summary:

This axisymmetric three-dimensional test makes it possible to validate calculations of the matrices of rigidity, mass and the vectors of pressure on all the elements 3D and 2D plane and axisymmetric deformations (10 modelings).

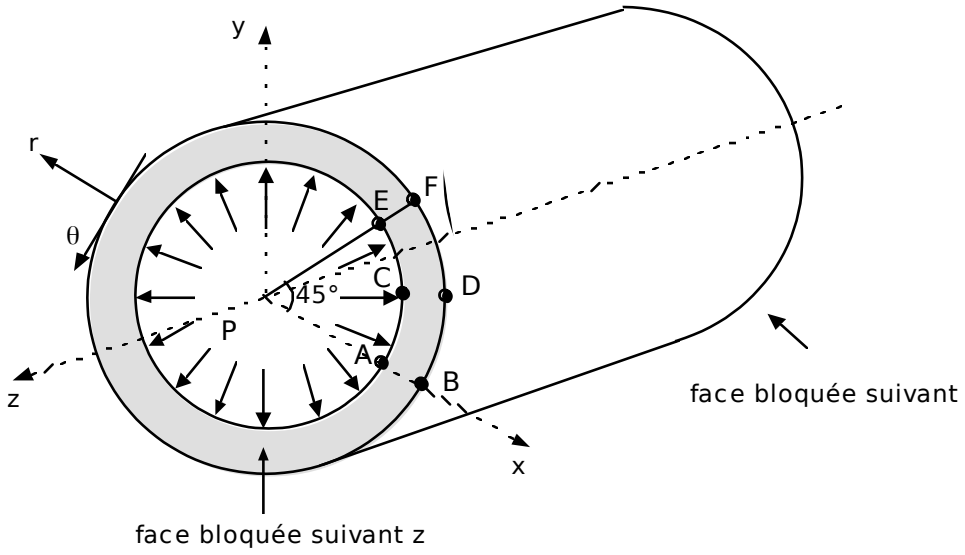
Displacements are imposed:

- maybe by degrees of freedom,
- maybe by face of element.

For four modelings 3D, the pressures applied are provided with the minus sign, because the faces of elements 3D are badly directed in the files of grid used.

1 Problem of reference

1.1 Geometry



internal ray $a=0.1\,m$
external ray $b=0.2\,m$

Coordinates of the points:

	A	B	C	D	E	F
x	0,100	0,200	$0.1\cos(22.5)$	$0.2\cos(22.5)$	$1/\sqrt{2}$	$\sqrt{2}$
y	0.	0.	$0.1\sin(22.5)$	$0.2\sin(22.5)$	$1/\sqrt{2}$	$\sqrt{2}$
z	0.	0.	0.	0.	0.	0.

1.2 Material properties

$E=26\,N/m^2$
$\nu=0.3$
$\rho=35\,Kg/m^3$

The very low value of the Young modulus does not have anything physics.

1.3 Boundary conditions and loadings

Internal pressure $P=p\,e^{j\omega t}$ with $p=1\,Mpa$ and $\omega=0.2\,rad/s$

1.4 Initial conditions

- without initial conditions,
- direct calculation of the harmonic solution.

2 Reference solution

2.1 Method of calculating used for the reference solution

$$u_r = A J_1(k_L r) + B Y_1(k_L r) \qquad u_\theta = u_z = 0$$

$$\sigma_{rr} = 2\mu K_L \left[A \left((2\gamma^2 - 1) J_0(k_L r) - \frac{1}{k_L r} J_1(k_L r) \right) + B \left(2\gamma^2 Y_0(k_L r) - \frac{1}{k_L r} Y_1(k_L r) \right) \right]$$

$$\sigma_{\theta\theta} = 2\mu K_L \left[A \left((2\gamma^2 - 1) J_0(k_L r) + \frac{1}{k_L r} J_1(k_L r) \right) + B \left(2\gamma^2 Y_0(k_L r) + \frac{1}{k_L r} Y_1(k_L r) \right) \right]$$

$$\sigma_{zz} = 2\mu K_L (2\gamma^2 - 1) \left[A J_0(k_L r) + B Y_0(k_L r) \right]$$

$$\sigma_{r\theta} = \sigma_{rz} = \sigma_{\theta z} = 0$$

avec : $\gamma^2 = \frac{\lambda + 2\mu}{4\mu} = \frac{1-\nu}{2(1-\nu)} = \frac{1}{4\beta^2}$ $\qquad k_L = \frac{\omega}{C_L} = \omega \sqrt{\frac{\rho}{\lambda + 2\mu}}$

J_1, J_0, Y_1, Y_0 : Fonctions de Bessel.

Constants A and B are calculated by solving the linear system obtained while writing:

$$\sigma_{rr}(a) = -p \quad \sigma_{rr}(b) = 0$$

One obtains:

For $r = 0.1$	$u_r = 7.3398\,10^{-3}$	For $r = 0.2$	$u_r = 4.6816\,10^{-3}$
	$\sigma_{rr} = -1$		$\sigma_{rr} = 0.$
	$\sigma_{\theta\theta} = 1.6685$		$\sigma_{\theta\theta} = 0.66738$
	$\sigma_{zz} = 0.20055$		$\sigma_{zz} = 0.20031$

Passage in the system of Cartesian axes:

$$\begin{aligned}
\sigma_{xx} &= \sigma_{rr}\cos^2\theta + \sigma_{\theta\theta}\sin^2\theta - 2\sigma_{r\theta}\sin\theta\cos\theta \\
\sigma_{yy} &= \sigma_{rr}\sin^2\theta + \sigma_{\theta\theta}\cos^2\theta + 2\sigma_{r\theta}\sin\theta\cos\theta \\
\sigma_{xy} &= \sigma_{rr}\sin\theta\cos\theta - \sigma_{\theta\theta}\sin\theta\cos\theta - 2\sigma_{r\theta}(\cos^2\theta - \sin^2\theta)
\end{aligned}$$

with:

$\theta = 0°$ at the points A and B

$\theta = 22.5°$ at the points C and D

$\theta = 45°$ at the points E and F

2.2 Results of reference

Displacements (u, v) and constraints $(\sigma_{xx}, \sigma_{yy}, \sigma_{zz}, \sigma_{xy})$ at the points A, B, C, D, E, F.

2.3 Uncertainty on the solution

Precision of the calculation of the Functions of Bessel.

2.4 Bibliographical references

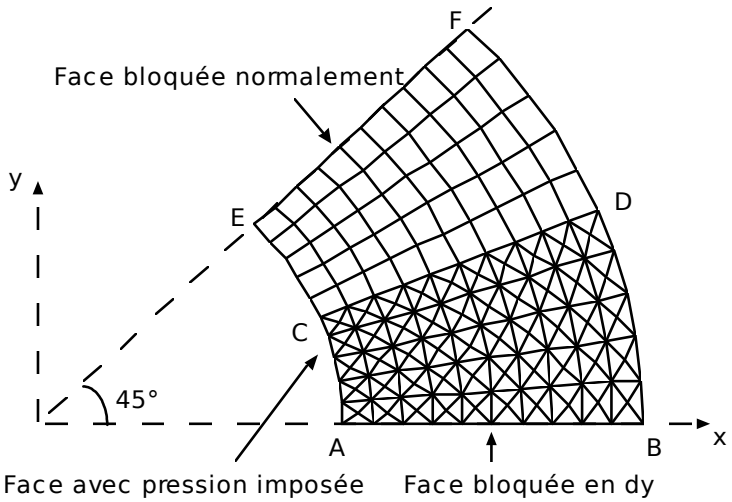
1) MR. BONNET: Methods of the integral equations regularized into elastodynamic - Bulletin of DER - Series C - N°1/2 - (1987).

2) ERINGEN - SUHUBI - Elastodynamics, Vol.2: linear theory Academic Close (1975).

3 Modeling A

3.1 Characteristics of modeling

Elements $3D$ (PENTA6 and HEXA8) (resulting from the grid $2D$ below).



along the axis Z : 2 layers of elements total thickness: 0.01

Limiting conditions:

	DDL_IMPO:	(All: 'yes'	Dz: 0.)
face AB		(Group_no: BordAB	Dy: 0.)
face EF	FACE_IMPO:	(Group_ma: FaceEF	Dnor: 0.)
pressure on the face AE	PRES_REP:	(Group_ma: FaceAE	Near: -1.)

Names of the nodes: A=No1 B=No119 C=No36 D=No166 E=No41 F=No171

3.2 Characteristics of the grid

Many nodes: 513
Many meshs and types: 400 PENTA6 100 HEXA8 40 QUAD4

3.3 Remarks

The pressure has a negative sign (instead of positive) because the faces of the elements $3D$ are badly directed.

3.4 Sizes tested and results

Localization	Sizes	Reference	*Aster*	% difference	tolerance
With	u	7.3398 10^{-3}	7.3243 10^{-3}	– 0.21	10^{-2}
	v	0.	eps	–	
	σ_{xx}	– 1.	– 0.8789	12.1	0.2
	σ_{yy}	1.6685	1.6241	– 2.66	
	σ_{zz}	0.20055	0.2235	11.75	
	σ_{xy}	0.	– 0.0922	–	0.2
C	u	6.78109 10^{-3}	6.7670 10^{-3}	– 0.21	10^{-2}
	v	2.80882 10^{-3}	2.8012 10^{-3}	– 0.27	0.3
	σ_{xx}	– 0.60921	– 0.5121	15.94	0.3
	σ_{yy}	1.27771	1.3300	4.09	0.3
	σ_{zz}	0.20055	0.2454	22.39	0.3
	σ_{xy}	– 0.94346	– 0.8567	9.20	0.3
E	u	5.19002 10^{-3}	5.1784 10^{-3}	– 0.22	10^{-2}
	v	5.19002 10^{-3}	5.1784 10^{-3}	– 0.22	0.6
	σ_{xx}	0.33425	0.4319	29.23	0.6
	σ_{yy}	0.33425	0.5315	59.04	0.6
	σ_{zz}	0.20055	0,289	44.50	0.6
	σ_{xy}	– 1.33425	– 1,269	4.87	
B	u	4.6716 10^{-3}	4.6641 10^{-3}	– 0.16	10^{-2}
	v	0.	eps	–	
	σ_{xx}	0.	– 0.0132	–	
	σ_{yy}	0.66738	0.6724	0.75	2.10^{-2}
	σ_{zz}	0.20021	0.1977	– 1.25	–
	σ_{xy}	0.	0.0219	–	–
D	u	4.32523 10^{-3}	4.3084 10^{-3}	– 0.39	10^{-2}
	v	1.79157 10^{-3}	1.7854 10^{-3}	– 0.34	0.3
	σ_{xx}	0.09774	0.0739	– 24.39	0.3
	σ_{yy}	0.56964	0.5728	0.56	0.3
	σ_{zz}	0.20021	0.1941	– 3.05	0.3
	σ_{xy}	– 0.23595	– 0.2348	0.49	0.3
F	u	3.31039 10^{-3}	3.2974 10^{-3}	– 0.39	10^{-2}
	v	3.31039 10^{-3}	3.2974 10^{-3}	– 0.39	0.2
	σ_{xx}	0.33369	0.2977	– 10.78	0.2
	σ_{yy}	0.33369	0.3245	2.75	0.2
	σ_{zz}	0.20021	0.1866	– 6.80	0.2
	σ_{xy}	– 0.33369	– 0.3415	– 2.34	0.2

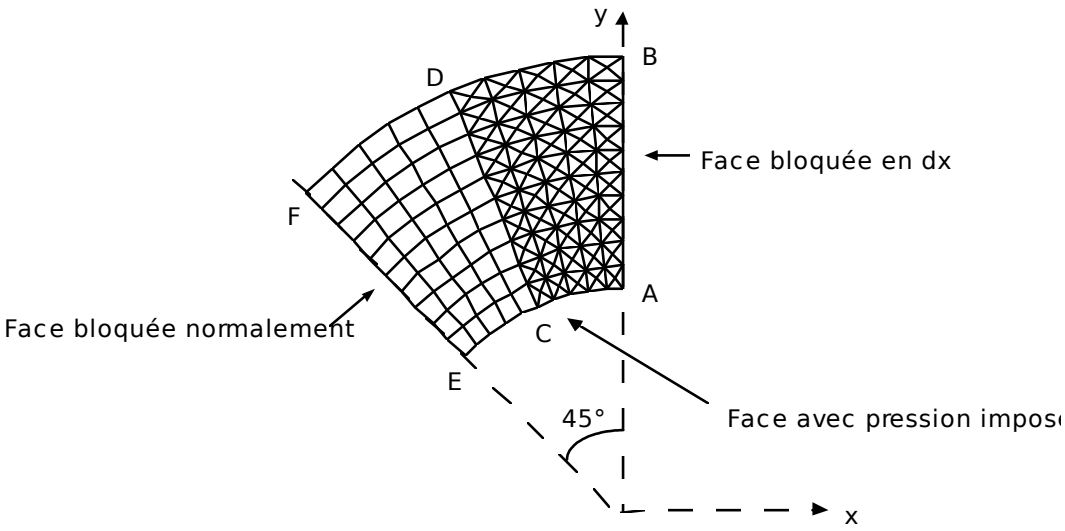
3.5 Remarks

The grid is insufficient for linear elements.

4 Modeling B

4.1 Characteristics of modeling

Elements $3D$ (PENTA15 and HEXA20) (resulting from the grid $2D$ below).



along the axis Z : 2 layers of elements total thickness: 0.01

Limiting conditions:

	DDL_IMPO:	(All: 'yes'	Dz: 0.)
face AB		(Group_no: BordAB	Dx: 0.)
face EF	FACE_IMPO:	(Group_ma: FaceEF	Dnor: 0.)
pressure on the face AE	PRES_REP:	(Group_ma: FaceAE	Near: -1.)

Names of the nodes: A=No2 B=No361 C=No121 D=No584 E=No155 F=No503

4.2 Characteristics of the grid

Many nodes: 2115
Many meshs and types: 400 PENTA15 100 HEXA20 40 QUAD8

4.3 Remarks

The pressure has a negative sign (instead of positive) because the faces of the elements $3D$ are badly directed.

4.4 Sizes tested and results

Localization	Sizes	Reference	*Aster*	% difference	tolerance
With	u	0.	eps	–	
	v	7.3398 10^{-3}	7.3326 10^{-3}	– 0.10	10^{-2}
	σ_{xx}	1.6685	1.6669	– 0.09	10^{-2}
	σ_{yy}	– 1.	– 0.9959	0.41	10^{-2}
	σ_{zz}	0.20055	0.2013	0.37	10^{-2}
	σ_{xy}	0.	3.3234 10^{-3}	–	10^{-2}
C	u	– 2.80882 10^{-3}	– 2.8063 10^{-3}	– 0.09	10^{-2}
	v	6.78109 10^{-3}	6.7745 10^{-3}	– 0.10	10^{-2}
	σ_{xx}	1.27771	1,278	0.02	10^{-2}
	σ_{yy}	– 0.60921	– 0.6078	0.23	10^{-2}
	σ_{zz}	0.20055	0.20107	0.26	10^{-2}
	σ_{xy}	0.94346	0.94027	0.34	10^{-2}
E	u	– 5.19002 10^{-3}	– 5.1851 10^{-3}	– 0.09	10^{-2}
	v	5.19002 10^{-3}	5.1851 10^{-3}	– 0.10	10^{-2}
	σ_{xx}	0.33425	0.3346	0.10	10^{-2}
	σ_{yy}	0.33425	0.3340	– 0.07	10^{-2}
	σ_{zz}	0.20055	0.2006	0.02	10^{-2}
	σ_{xy}	1.33425	1,331	– 0.24	10^{-2}
B	u	0.	eps	–	
	v	4.6716 10^{-3}	4.6682 10^{-3}	– 0.07	10^{-2}
	σ_{xx}	0.66738	0.6675	0.02	10^{-2}
	σ_{yy}	0.	3.2779 10^{-4}	–	10^{-2}
	σ_{zz}	0.20021	0.2003	0.04	10^{-2}
	σ_{xy}	0.	– 5.0918 10^{-4}	–	10^{-2}
D	u	– 1.79157 10^{-3}	– 1.7864 10^{-3}	– 0.29	10^{-2}
	v	4.32523 10^{-3}	4.3129 10^{-3}	– 0.29	10^{-2}
	σ_{xx}	0.56964	0.56957	– 0.01	10^{-2}
	σ_{yy}	0.09774	0.09803	0.30	10^{-2}
	σ_{zz}	0.20021	0.20027	0.03	10^{-2}
	σ_{xy}	0.23595	0.23623	0.12	10^{-2}
F	u	– 3.31039 10^{-3}	– 3.3009 10^{-3}	– 0.29	10^{-2}
	v	3.31039 10^{-3}	3.3009 10^{-3}	– 0.29	10^{-2}
	σ_{xx}	0.33369	0.3337	– 0,003	10^{-3}
	σ_{yy}	0.33369	0.3337	0,003	10^{-3}
	σ_{zz}	0.20021	0.2002	0.	10^{-3}
	σ_{xy}	0.33369	0.3339	0.06	10^{-3}

5 Modeling C

5.1 Characteristics of modeling

Elements 3D (TETRA4)

along the axis Z : 2 layers of elements total thickness: 0.01

Limiting conditions:

	DDL_IMPO:	(All: 'yes'	Dz: 0.)
face AB		(Group_no: BordAB	Dy: 0.)
face EF	FACE_IMPO:	(Group_ma: FaceEF	Dnor: 0.)
pressure on the face AE	PRES_REP:	(Group_ma: FaceAE	Near: -1.)

Names of the nodes:	A=No3	B=No7	C=No4	D=No8	E=No154	F=No156
plan $z=0.005$	A2=No1	B2=No5	C2=No2	D2=No6	E2=No153	F2=No155
plan $z=0.01$	A3=No283	B3=No285	C3=No284	D3=No286	E3=No359	F3=No360

5.2 Characteristics of the grid

Many nodes: 423
Many meshs and types: 1416 TETRA4 72 TRIA3

5.3 Remarks

The pressure has a negative sign (instead of positive) because the faces of the elements $3D$ are badly directed.

5.4 Sizes tested and results

Localization	Sizes	Reference	*Aster*	% difference	tolerance
With	u	7.3398 10^{-3}	7.3331 10^{-3}	– 0.10	10^{-2}
	v	0.	eps	-	
	σ_{xx}	– 1.	– 0.9000	+10.00	0.02
	σ_{yy}	1.6685	1.6809	0.74	0.02
	σ_{zz}	0.20055	0.2343	16.83	0.02
	σ_{xy}	0.	0.1016	-	0.02
C	u	6.78109 10^{-3}	6.7783 10^{-3}	– 0.04	10^{-2}
	v	2.80882 10^{-3}	2.8077 10^{-3}	– 0.04	
	σ_{xx}	– 0.60921	– 0.5061	16.92	0.04
	σ_{yy}	1.27771	1.3184	3.18	0.04
	σ_{zz}	0.20055	0.2437	21.51	0.04
	σ_{xy}	– 0.94346	– 0.9123	3.30	0.04
E	u	5.19002 10^{-3}	5.1853 10^{-3}	– 0.09	10^{-2}
	v	5.19002 10^{-3}	5.1853 10^{-3}	– 0.09	
	σ_{xx}	0.33425	0.2888	– 13.60	0.5
	σ_{yy}	0.33425	0.4920	47.19	0.5
	σ_{zz}	0.20055	0.2343	16.83	0.5
	σ_{xy}	– 1.33425	– 1.2905	3.28	0.5
B	u	4.6716 10^{-3}	4.6634 10^{-3}	– 0.18	10^{-2}
	v	0.	eps	-	
	σ_{xx}	0.	0.0146	-	
	σ_{yy}	0.66738	0.6570	– 1.55	5.10^{-2}
	σ_{zz}	0.20021	0.1976	– 1.30	5.10^{-2}
	σ_{xy}	0.	– 0.0159	-	5.10^{-2}
D	u	4.32523 10^{-3}	4.2960 10^{-3}	– 0.68	10^{-2}
	v	1.79157 10^{-3}	1.7795 10^{-3}	– 0.67	
	σ_{xx}	0.09774	0.0824	– 15.69	0.2
	σ_{yy}	0.56964	0.5809	1.97	0.2
	σ_{zz}	0.20021	0.1921	– 4.05	0.2
	σ_{xy}	– 0.23595	– 0.2378	– 7.84	0.2
F	u	3.31039 10^{-3}	3.2976 10^{-3}	– 0.39	10^{-2}
	v	3.31039 10^{-3}	3.2975 10^{-3}	– 0.39	
	σ_{xx}	0.33369	0.3052	– 8.54	0.1
	σ_{yy}	0.33369	0.3371	1.02	0.1
	σ_{zz}	0.20021	0.1921	– 4.05	0.1
	σ_{xy}	– 0.33369	– 0.3358	– 0.63	0.1

5.5 Remarks

One notes a variation ($< 0.24\%$) displacements for the points of the plan $z = 0.005$.
The grid is insufficient for linear elements.

6 Modeling D

6.1 Characteristics of modeling

Elements 3D (TETRA10)

along axis Z: 2 layers of elements total thickness: 0.01

Limiting conditions:

	DDL_IMPO:	(All: 'yes'	Dz: 0.)
face AB		(Group_no: BordAB	Dy: 0.)
face EF	FACE_IMPO:	(Group_ma: FaceEF	Dnor: 0.)
pressure on the face AE	PRES_REP:	(Group_ma: FaceAE	Near: -1.)

Names of the nodes:	A=No3	B=No7	C=No4	D=No8	E=No1228	F=No230
plan Z = 0,005	A2=No1	B2=No5	C2=No2	D2=No6	E2=No227	F2=No229
plan Z = 0.01	A3=No420	B3=No422	C3=No421	D3=No423	E3=No573	F3=No574

6.2 Characteristics of the grid

Many nodes: 703
Many meshs and types: 356 TETRA10 36 TRIA6

6.3 Remarks

The pressure has a negative sign (instead of positive) because the faces of the elements $3D$ are badly directed.

6.4 Sizes tested and results

Localization	Sizes	Reference	*Aster*	% difference	tolerance
With	u	7.3398 10^{-3}	7.3522 10^{-3}	0.10	10^{-2}
	v	0.	eps	-	10^{-2}
	σ_{xx}	– 1.	– 0.9925	0.75	$5{\cdot}10^{-2}$
	σ_{yy}	1.6685	1.6725	0.24	$5{\cdot}10^{-2}$
	σ_{zz}	0.20055	0.2040	– 1.72	$5{\cdot}10^{-2}$
	σ_{xy}	0.	– 0.0365	-	$5{\cdot}10^{-2}$
C	u	6.78109 10^{-3}	6.7836 10^{-3}	0.04	10^{-2}
	v	2.80882 10^{-3}	2.8099 10^{-3}	0.04	10^{-2}
	σ_{xx}	– 0.60921	– 0.5977	1.89	$5{\cdot}10^{-2}$
	σ_{yy}	1.27771	1,294	1.28	$5{\cdot}10^{-2}$
	σ_{zz}	0.20055	0.2088	4.11	$5{\cdot}10^{-2}$
	σ_{xy}	– 0.94346	– 0.9457	– 0.24	$5{\cdot}10^{-2}$
E	u	5.19002 10^{-3}	5.1988 10^{-3}	0.17	10^{-2}
	v	5.19002 10^{-3}	5.1988 10^{-3}	0.17	10^{-2}
	σ_{xx}	0.33425	0.3035	– 9.20	0.15
	σ_{yy}	0.33425	0.3766	12.67	0.15
	σ_{zz}	0.20055	0.2040	1.72	0.15
	σ_{xy}	– 1.33425	– 1,332	0.17	0.15
B	u	4.6716 10^{-3}	4.6711 10^{-3}	– 0.01	10^{-2}
	v	0.	eps	-	10^{-2}
	σ_{xx}	0.	8,597 10^{-4}	-	10^{-2}
	σ_{yy}	0.66738	0.6679	0.08	10^{-2}
	σ_{zz}	0.20021	0.2006	0.19	10^{-2}
	σ_{xy}	0.	1.0181 10^{-3}	-	10^{-2}
D	u	4.32523 10^{-3}	4.3134 10^{-3}	– 0.28	10^{-2}
	v	1.79157 10^{-3}	1.7867 10^{-3}	– 0.28	10^{-2}
	σ_{xx}	0.09774	0.09418	– 3.64	$5{\cdot}10^{-2}$
	σ_{yy}	0.56964	0.5652	– 0.78	$5{\cdot}10^{-2}$
	σ_{zz}	0.20021	0.1978	– 1.20	$5{\cdot}10^{-2}$
	σ_{xy}	– 0.23595	– 0.2355	0.19	$5{\cdot}10^{-2}$
F	u	3.31039 10^{-3}	3.3029 10^{-3}	– 0.23	10^{-2}
	v	3.31039 10^{-3}	3.3029 10^{-3}	– 0.23	10^{-2}
	σ_{xx}	0.33369	0.3357	0.60	10^{-2}
	σ_{yy}	0.33369	0.3334	– 0.09	10^{-2}
	σ_{zz}	0.20021	0.2007	0.24	10^{-2}
	σ_{xy}	– 0.33369	– 0.3336	-	10^{-2}

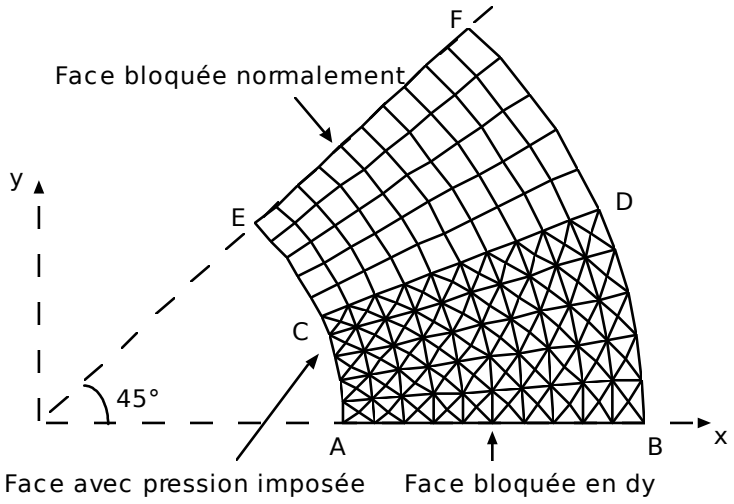
6.5 Remarks

One notes a variation ($< 0.23\%$) displacements for the points of the plan $z = 0.005$.

7 Modeling E

7.1 Characteristics of modeling

Elements D_PLAN (TRIA3 + QUAD4)



Limiting conditions:

side AB	DDL_IMPO:	(Group_no: GRNM11	Dy: 0.)
side EF	FACE_IMPO:	(Group_ma: GRMA12	Dnor: 0.)
pressure on AE	PRES_REP:	(Group_ma: GRMA13	Near: 1.)

Names of the nodes: $A=N1$ $B=N119$ $C=N36$ $D=N166$ $E=N41$ $F=N171$

7.2 Characteristics of the grid

Many nodes: 171
Many meshs and types: 200 TRIA3 50 QUAD4

7.3 Sizes tested and results

Localization	Sizes	Reference	*Aster*	% difference	tolerance
With	u	7.3398 10^{-3}	7.3243 10^{-3}	– 0.21	10^{-2}
	v	0.	eps	-	
	σ_{xx}	– 1.	– 0.8790	12.10	0.15
	σ_{yy}	1.6685	1.6241	– 2.66	0.15
	σ_{zz}	0.20055	0.2235	11.44	0.15
	σ_{xy}	0.	– 0.0922	-	0.15
C	u	6.78109 10^{-3}	6.7670 10^{-3}	– 0.21	10^{-2}
	v	2.80882 10^{-3}	2.8012 10^{-3}	– 0.27	
	σ_{xx}	– 0.60921	– 0.5122	– 15.92	0.3
	σ_{yy}	1.27771	1.3302	4.11	0.3
	σ_{zz}	0.20055	0.2454	22.36	0.3
	σ_{xy}	– 0.94346	– 0.8567	– 9.19	0.3
E	u	5.19002 10^{-3}	5.1784 10^{-3}	– 0.22	10^{-2}
	v	5.19002 10^{-3}	5.1784 10^{-3}	– 0.22	
	σ_{xx}	0.33425	0.4318	29.18	0.6
	σ_{yy}	0.33425	0.5315	59.01	0.6
	σ_{zz}	0.20055	0.2890	44.10	0.6
	σ_{xy}	– 1.33425	– 1.2686	4.92	0.6
B	u	4.6716 10^{-3}	4.6641 10^{-3}	– 0.16	10^{-2}
	v	0.	eps	-	
	σ_{xx}	0.	– 1.3198 10^{-2}	-	0.05
	σ_{yy}	0.66738	0.6723	0.74	0.05
	σ_{zz}	0.20021	0.1977	– 1.25	0.05
	σ_{xy}	0.	– 0.0219	-	0.05
D	u	4.32523 10^{-3}	4.3084 10^{-3}	– 0.39	10^{-2}
	v	1.79157 10^{-3}	1.7854 10^{-3}	– 0.39	
	σ_{xx}	0.09774	0.07393	– 24.36	0.3
	σ_{yy}	0.56964	0.5728	0.55	0.3
	σ_{zz}	0.20021	0.1940	– 3.10	0.3
	σ_{xy}	– 0.23595	– 0.2347	0.53	0.3
F	u	3.31039 10^{-3}	3.2974 10^{-3}	– 0.39	10^{-2}
	v	3.31039 10^{-3}	3.2974 10^{-3}	– 0.39	
	σ_{xx}	0.33369	0.2976	– 10.81	0.15
	σ_{yy}	0.33369	0.3245	– 2.75	0.15
	σ_{zz}	0.20021	0.1866	– 6.80	0.15
	σ_{xy}	– 0.33369	– 0.3415	– 2.34	0.15

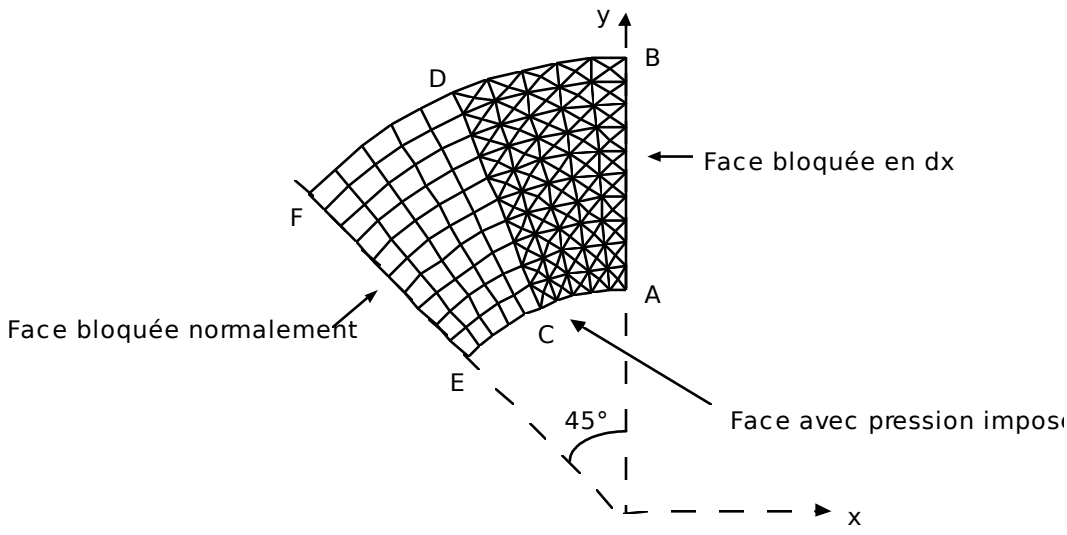
7.4 Remarks

The grid is insufficient for linear elements.

8 Modeling F

8.1 Characteristics of modeling

Elements D_PLAN (QUAD8 + TRIA6)



Limiting conditions:

side AB	DDL_IMPO:	(Group_no: GRNM11	Dy: 0.)
side EF	FACE_IMPO:	(Group_ma: GRMA12	Dnor: 0.)
pressure on AE	PRES_REP:	(Group_ma: GRMA13	Near: 1.)

Names of the nodes: $A=N2$ $B=N361$ $C=N121$ $D=N584$ $E=N155$ $F=N503$

8.2 Characteristics of the grid

Many nodes: 591
Many meshs and types: 200 TRIA6 50 QUAD8

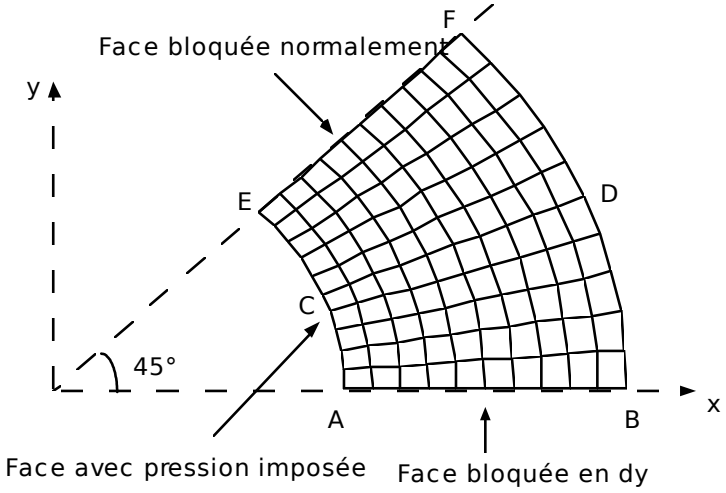
8.3 Sizes tested and results

Localization	Sizes	Reference	*Aster*	% difference	tolerance
With	u	0.	0.	-	10^{-2}
	v	7.3398 10^{-3}	7.3326 10^{-3}	– 0.10	10^{-2}
	σ_{xx}	1.6685	1.6669	0.09	10^{-2}
	σ_{yy}	– 1.	– 0.9959	0.41	10^{-2}
	σ_{zz}	0.20055	0.20129	0.37	10^{-2}
	σ_{xy}	0.	0.00332	-	10^{-2}
C	u	– 2.80882 10^{-3}	– 2.8063 10^{-3}	– 0.09	10^{-2}
	v	6.78109 10^{-3}	6.7745 10^{-3}	– 0.10	10^{-2}
	σ_{xx}	1.27771	1.27799	0.02	10^{-2}
	σ_{yy}	– 0.60921	– 0.60779	0.23	10^{-2}
	σ_{zz}	0.20055	0.20106	0.25	10^{-2}
	σ_{xy}	0.94346	0.94027	– 0.34	10^{-2}
E	u	– 5.19002 10^{-3}	– 5.1851 10^{-3}	– 0.09	10^{-2}
	v	5.19002 10^{-3}	5.1851 10^{-3}	– 0.09	10^{-2}
	σ_{xx}	0.33425	0.33462	0.11	10^{-2}
	σ_{yy}	0.33425	0.33403	– 0,066	10^{-2}
	σ_{zz}	0.20055	0.20059	0.02	10^{-2}
	σ_{xy}	1.33425	1.33117	– 0.23	10^{-2}
B	u	0.	eps	-	10^{-2}
	v	4.6716 10^{-3}	4.6682 10^{-3}	– 0.07	10^{-2}
	σ_{xx}	0.66738	0.66758	0.03	10^{-2}
	σ_{yy}	0.	0.00033	-	10^{-2}
	σ_{zz}	0.20021	0.20037	0.08	10^{-2}
	σ_{xy}	0.	– 5.1132 10^{-4}	-	10^{-2}
D	u	– 1.79157 10^{-3}	– 1.7865 10^{-3}	– 0.28	10^{-2}
	v	4.32523 10^{-3}	4.3129 10^{-3}	– 0.28	10^{-2}
	σ_{xx}	0.56964	0.56962	– 0,003	10^{-2}
	σ_{yy}	0.09774	0.09805	0.32	10^{-2}
	σ_{zz}	0.20021	0.200298	0,044	10^{-2}
	σ_{xy}	0.23595	0.23623	0.12	10^{-2}
F	u	– 3.31039 10^{-3}	– 3.3009 10^{-3}	– 0.29	10^{-2}
	v	3.31039 10^{-3}	3.3009 10^{-3}	– 0.29	10^{-2}
	σ_{xx}	0.33369	0.33371	0,006	10^{-2}
	σ_{yy}	0.33369	0.33366	– 0,009	10^{-2}
	σ_{zz}	0.20021	0.20021	0.	10^{-2}
	σ_{xy}	0.33369	0.33392	0,069	10^{-2}

9 Modeling G

9.1 Characteristics of modeling

D_PLAN (QUAD9)



Limiting conditions:

side AB	DDL_IMPO:	(Group_no: GRNM11	Dy: 0.)
side EF	FACE_IMPO:	(Group_ma: GRMA12	Dnor: 0.)
pressure on AE	PRES_REP:	(Group_ma: GRMA13	Near: 1.)

Names of the nodes: $A=N1$ $B=N347$ $C=N21$ $D=N432$ $E=N39$ $F=N229$

9.2 Characteristics of the grid

Many nodes: 441
Many meshs and types: 100 QUAD9

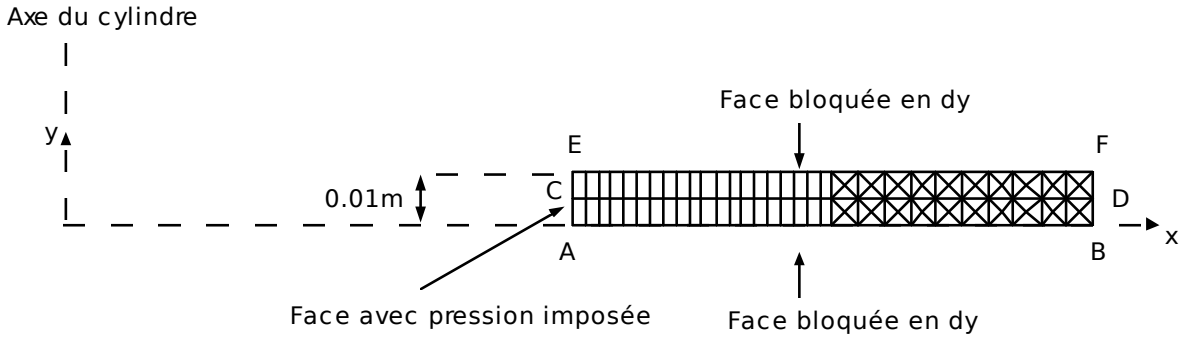
9.3 Sizes tested and results

Localization	Sizes	Reference	*Aster*	% difference	tolerance
With	u	7.3398 10^{-3}	7.3329 10^{-3}	– 0.09	10^{-2}
	v	0.	eps	-	10^{-2}
	σ_{xx}	– 1.	– 0.9968	0.32	10^{-2}
	σ_{yy}	1.6685	1.6655	– 0.18	10^{-2}
	σ_{zz}	0.20055	0.20059	0.02	10^{-2}
	σ_{xy}	0.	– 2.97 10^{-4}	-	10^{-2}
C	u	6.78109 10^{-3}	6.7747 10^{-3}	– 0.09	10^{-2}
	v	2.80882 10^{-3}	2.8062 10^{-3}	– 0.09	10^{-2}
	σ_{xx}	– 0.60921	– 0.60695	0.37	10^{-2}
	σ_{yy}	1.27771	1.27563	– 0.16	10^{-2}
	σ_{zz}	0.20055	0.20060	0.02	10^{-2}
	σ_{xy}	– 0.94346	– 0.94128	– 0.23	10^{-2}
E	u	5.19002 10^{-3}	5.1851 10^{-3}	– 0.09	10^{-2}
	v	5.19002 10^{-3}	5.1851 10^{-3}	– 0.09	10^{-2}
	σ_{xx}	0.33425	0.33403	– 0.06	10^{-2}
	σ_{yy}	0.33425	0.33463	0.11	10^{-2}
	σ_{zz}	0.20055	0.20059	0.02	10^{-2}
	σ_{xy}	– 1.33425	– 1.33117	0.23	10^{-2}
B	u	4.6716 10^{-3}	4.6682 10^{-3}	– 0.07	10^{-2}
	v	0.	eps	-	10^{-2}
	σ_{xx}	0.	– 2,394 10^{-3}	-	10^{-2}
	σ_{yy}	0.66738	0.66759	0.03	10^{-2}
	σ_{zz}	0.20021	0.200207	– 0,001	10^{-2}
	σ_{xy}	0.	– 2.65 10^{-5}	-	10^{-2}
D	u	4.32523 10^{-3}	4.3128 10^{-3}	– 0.29	10^{-2}
	v	1.79157 10^{-3}	1.7864 10^{-3}	– 0.29	10^{-2}
	σ_{xx}	0.09774	0.09756	– 0.18	10^{-2}
	σ_{yy}	0.56964	0.56979	0.02	10^{-2}
	σ_{zz}	0.20021	0.200206	– 0,002	10^{-2}
	σ_{xy}	– 0.23595	– 0.23611	– 0.07	10^{-2}
F	u	3.31039 10^{-3}	3.3009 10^{-3}	– 0.29	10^{-2}
	v	3.31039 10^{-3}	3.3009 10^{-3}	– 0.29	10^{-2}
	σ_{xx}	0.33369	0.33366	– 0,009	10^{-2}
	σ_{yy}	0.33369	0.33371	0,006	10^{-2}
	σ_{zz}	0.20021	0.20021	0.	10^{-2}
	σ_{xy}	– 0.33369	– 0.33392	– 0.07	10^{-2}

10 Modeling H

10.1 Characteristics of modeling

Elements axis (TRIA3 + QUAD4)



Limiting conditions:

side AB	DDL_IMPO:	(Group_no: GRNM11	Dy: 0.)
side EF	FACE_IMPO:	(Group_ma: GRMA12	Dnor: 0.)
pressure on AE	PRES_REP:	(Group_ma: GRMA13	Near: 1.)

Names of the nodes: $A=N111$ $B=N1$ $C=N112$ $D=N3$ $E=N113$ $F=N4$

10.2 Characteristics of the grid

Many nodes: 113
Many meshs and types: 40 QUAD4 80 TRIA3

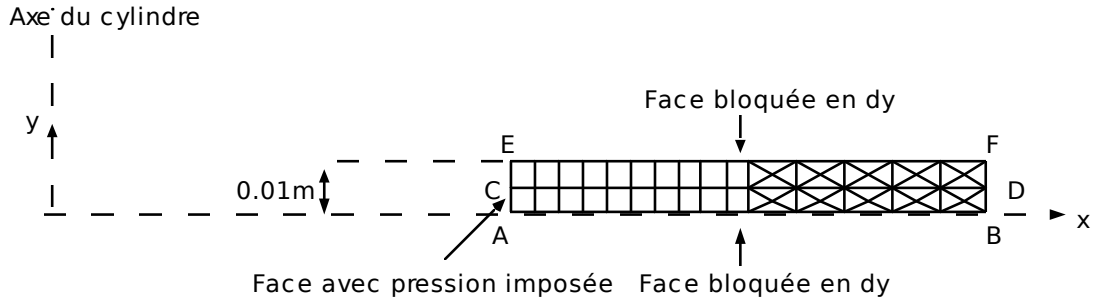
10.3 Sizes tested and results

Localization	Sizes	Reference	*Aster*	% difference	tolerance
With	u	7.3398 10^{-3}	7.3390 10^{-3}	– 0.01	10^{-2}
	v	0.	eps	-	
	σ_{xx}	– 1.	– 0.9430	– 5.72	0.2
	σ_{yy}	0.20055	0.2248	12.19	0.2
	σ_{zz}	1.6685	1.6923	1.46	0.2
	σ_{xy}	0.	eps	-	0.2
C	u	7.3398 10^{-3}	7.3390 10^{-3}	– 0.01	10^{-2}
	v	0.	eps	-	
	σ_{xx}	– 1.	– 0.9430	– 5.72	0.2
	σ_{yy}	0.20055	0.2248	12.19	0.2
	σ_{zz}	1.6685	1.6923	1.46	0.2
	σ_{xy}	0.	eps	-	0.2
E	u	7.3398 10^{-3}	7.3390 10^{-3}	– 0.01	10^{-2}
	v	0.	0·	-	
	σ_{xx}	– 1.	– 0.9430	– 5.72	0.2
	σ_{yy}	0.20055	0.2248	12.19	0.2
	σ_{zz}	1.6685	1.6923	1.46	0.2
	σ_{xy}	0.	eps	-	0.2
B	u	4.6716 10^{-3}	4.6713 10^{-3}	– 0.01	10^{-2}
	v	0.	eps	-	
	σ_{xx}	0.	– 0.0110	-	0.05
	σ_{yy}	0.20021	0.1954	– 2.35	0.05
	σ_{zz}	0.66738	0.6625	– 0.72	0.05
	σ_{xy}	0.	– 0.0011	-	0.05
D	u	4.6716 10^{-3}	4.6713 10^{-3}	– 0.01	10^{-2}
	v	0.	eps	-	
	σ_{xx}	0.	– 0.0110	-	0.05
	σ_{yy}	0.20021	0.1954	– 2.35	0.05
	σ_{zz}	0.66738	0.6625	– 0.72	0.05
	σ_{xy}	0.	eps	-	0.05
F	u	4.6716 10^{-3}	4.6713 10^{-3}	– 0.01	10^{-2}
	v	0.	eps	-	
	σ_{xx}	0.	– 0.0110	-	0.05
	σ_{yy}	0.20021	0.1954	– 2.35	0.05
	σ_{zz}	0.66738	0.6625	– 0.72	0.05
	σ_{xy}	0.	+0.0011	-	0.05

11 Modeling I

11.1 Characteristics of modeling

Elements axis (TRIA6 + QUAD8)



Limiting conditions:

side AB	DDL_IMPO:	(Group_no: GRNM11	Dy: 0.)
side EF	FACE_IMPO:	(Group_ma: GRMA12	Dnor: 0.)
pressure on AE	PRES_REP:	(Group_ma: GRMA13	Near: 1.)

Names of the nodes: $A=N8$ $B=N174$ $C=N5$ $D=N170$ $E=N3$ $F=N159$

11.2 Characteristics of the grid

Many nodes: 175
Many meshs and types: 20 QUAD8 40 TRIA6

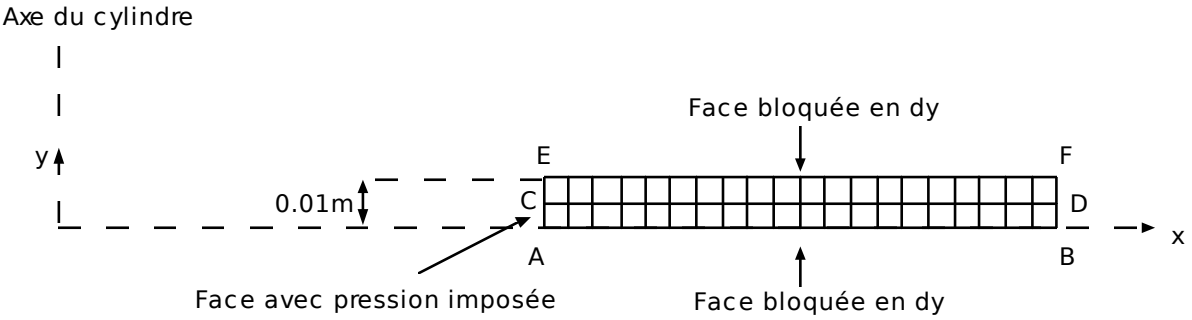
11.3 Sizes tested and results

Localization	Sizes	Reference	*Aster*	% difference	tolerance
With	u	7.3398 10^{-3}	7.3397 10^{-3}	– 0.00	10^{-2}
	v	0.	eps	-	10^{-2}
	σ_{xx}	– 1.	– 0.9984	– 0.16	10^{-2}
	σ_{yy}	0.20055	0.20055	-	10^{-2}
	σ_{zz}	1.6685	1,669	– 0.57	10^{-2}
	σ_{xy}	0.	eps	-	10^{-2}
C	u	7.3398 10^{-3}	7.3397 10^{-3}	– 0.00	10^{-2}
	v	0.	eps	-	10^{-2}
	σ_{xx}	– 1.	– 0.9984	– 0.16	10^{-2}
	σ_{yy}	0.20055	0.20055	-	10^{-2}
	σ_{zz}	1.6685	1,669	– 0.57	10^{-2}
	σ_{xy}	0.	eps	-	10^{-2}
E	u	7.3398 10^{-3}	7.3397 10^{-3}	– 0.00	10^{-2}
	v	0.	eps	-	10^{-2}
	σ_{xx}	– 1.	– 0.9984	– 0.16	10^{-2}
	σ_{yy}	0.20055	0.20055	-	10^{-2}
	σ_{zz}	1.6685	1,669	– 0.57	10^{-2}
	σ_{xy}	0.	eps	-	10^{-2}
B	u	4.6716 10^{-3}	4.6716 10^{-3}	0.00	10^{-2}
	v	0.	eps	-	10^{-2}
	σ_{xx}	0.	3.8 10^{-4}	-	10^{-2}
	σ_{yy}	0.20021	0.2002	-	10^{-2}
	σ_{zz}	0.66738	0.66716 10^{-5}	– 0.03	10^{-2}
	σ_{xy}	0.		-	10^{-2}
D	u	4.6716 10^{-3}	4.6716 10^{-3}	0.00	10^{-2}
	v	0.	eps	-	10^{-2}
	σ_{xx}	0.	3.8 10^{-4}	-	10^{-2}
	σ_{yy}	0.20021	0.2002	-	10^{-2}
	σ_{zz}	0.66738	0.66716	– 0.03	10^{-2}
	σ_{xy}	0.	eps	-	10^{-2}
F	u	4.6716 10^{-3}	4.6716 10^{-3}	0.00	10^{-2}
	v	0.	eps	-	10^{-2}
	σ_{xx}	0.	3.8 10^{-4}	-	10^{-2}
	σ_{yy}	0.20021	0.2002	-	10^{-2}
	σ_{zz}	0.66738	0.66716	– 0.03	10^{-2}
	σ_{xy}	0.	10^{-5}	-	10^{-2}

12 Modeling J

12.1 Characteristics of modeling

Elements axis (QUAD9)



Limiting conditions:

side AB	DDL_IMPO:	(Group_no: GRNM11	Dy: 0.)
side EF	FACE_IMPO:	(Group_ma: GRMA12	Dnor: 0.)
pressure on AE	PRES_REP:	(Group_ma: GRMA13	Near: 1.)

Names of the nodes: $A = N196$ $B = N1$ $C = N200$ $D = N5$ $E = N202$ $F = N7$

12.2 Characteristics of the grid

Many nodes: 205
Many meshs and types: 40 QUAD9

12.3 Sizes tested and results

Localization	Sizes	Reference	*Aster*	% difference	tolerance
With	u	7.3398 10^{-3}	7.3397 10^{-3}	– 0.00	10^{-2}
	v	0.	eps	-	10^{-2}
	σ_{xx}	– 1.	– 0.9984	+0.16	10^{-2}
	σ_{yy}	0.20055	0.2005	-	10^{-2}
	σ_{zz}	1.6685	1,667	– 0.57	10^{-2}
	σ_{xy}	0.	eps	-	10^{-2}
C	u	7.3398 10^{-3}	7.3397 10^{-3}	– 0.00	10^{-2}
	v	0.	eps	-	10^{-2}
	σ_{xx}	– 1.	– 0.9984	+0.16	10^{-2}
	σ_{yy}	0.20055	0.2005	-	10^{-2}
	σ_{zz}	1.6685	1,667	– 0.57	10^{-2}
	σ_{xy}	0.	eps	-	10^{-2}
E	u	7.3398 10^{-3}	7.3397 10^{-3}	– 0.00	10^{-2}
	v	0.	eps	-	10^{-2}
	σ_{xx}	– 1.	– 0.9984	+0.16	10^{-2}
	σ_{yy}	0.20055	0.2005	-	10^{-2}
	σ_{zz}	1.6685	1,667	– 0.57	10^{-2}
	σ_{xy}	0.	eps	-	10^{-2}
B	u	4.6716 10^{-3}	4.6716 10^{-3}	0.00	10^{-2}
	v	0.	eps	-	10^{-2}
	σ_{xx}	0.	1.1 10^{-4}	-	10^{-2}
	σ_{yy}	0.20021	0.20021	-	10^{-2}
	σ_{zz}	0.66738	0.66727	– 0.04	10^{-2}
	σ_{xy}	0.	eps	-	10^{-2}
D	u	4.6716 10^{-3}	4.6716 10^{-3}	0.00	10^{-2}
	v	0.	eps	-	10^{-2}
	σ_{xx}	0.	1.1 10^{-4}	-	10^{-2}
	σ_{yy}	0.20021	0.20021	-	10^{-2}
	σ_{zz}	0.66738	0.66727	– 0.04	10^{-2}
	σ_{xy}	0.	eps	-	10^{-2}
F	u	4.6716 10^{-3}	4.6716 10^{-3}	0.00	10^{-2}
	v	0.	eps	-	10^{-2}
	σ_{xx}	0.	1.1 10^{-4}	-	10^{-2}
	σ_{yy}	0.20021	0.20021	0.02	10^{-2}
	σ_{zz}	0.66738	0.66727	– 0.04	10^{-2}
	σ_{xy}	0.	eps	-	10^{-2}

13 Summary of the results

Summary errors		3 D			D_PLAN			Axis		
max in %	MOD A	MOD B	MOD C	MOD D	MOD E	MOD F	MOD G	MOD H	MOD I	MOD J
Displacements										
WITH, C, E B, D, F	– 0.27 – 0.39	– 0.10 – 0.02	– 0.10 – 0.68	0.17 – 0.28	– 0.27 – 0.39	– 0.10 – 0.29	– 0.09 – 0.29	– 0.01 – 0.01	0.00 0.00	– 0.00 – 0.00
Constraints	σ_{xx}									
WITH, C, E B, D, F	29.23 – 24.39	0.10 0.02	16.92 – 15.69	– 9.20 – 3.64	29.18 – 24.36	0.11 0.03	0.37 – 0.18	5.72 -	0.27 -	0.27 -
Constraints	σ_{yy}									
WITH, C, E B, D, F	59.04 2.75	0.41 0.30	47.19 1.97	12.67 – 0.78	59.01 – 2.75	0.41 0.32	– 0.18 0.03	12.19 – 2.35	0.09 0.09	0.09 0.02
Constraints	σ_{zz}									
WITH, C, E B, D, F	44.50 – 6.80	0.37 0.04	21.51 – 4.05	4.11 – 1.20	44.10 – 6.80	0.37 0.08	0.02 – 0,001	1.46 – 0.72	0.57 0.03	0.57 0.04
Constraints	σ_{xy}									
WITH, C, E B, D, F	9.20 – 2.34	0.34 0.12	3.30 – 7.84	– 0.24 0.19	– 9.19 – 2.34	– 0.34 0.12	0.23 – 0.07	- -	- -	- -

- The grids for the elements of order 1 are not fine enough.
- The results are more precise with elements of order 2.
- The problem is adapted more to an axisymmetric modeling (H, I, J) - > better results.
- Results of the elements $3D$ and of the elements plans having spaces of interpolation in correspondence are identical.
- Results of the axisymmetric elements QUAD8 and QUAD9 are identical.