SSLS100 - Subjected embedded circular plate with a uniform pressure

Summary:

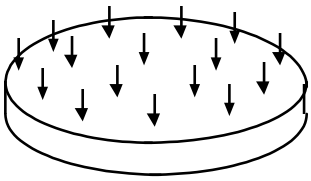
This problem allows a comparison between the solutions obtained and various elements of plate in linear elasticity:

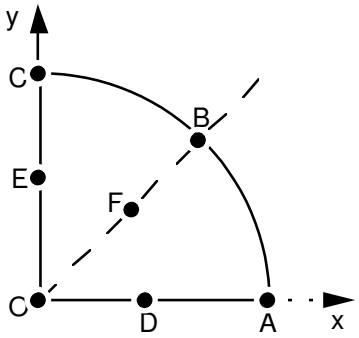
- models of **Coil-Kirchhoff** (plate known as thin):
  - triangular surface mesh (TRIA3) DKT,
  - quadrangular surface mesh (QUAD4) DKQ,
  - linear mesh (SEG3) COQUE_AXIS,
- models of **Mindlin-Reissner** (plate known as thick):
  - triangular surface mesh (TRIA3) DST,
  - quadrangular surface mesh (QUAD4) DSQ,
  - linear mesh (SEG3) COQUE_AXIS,
- models of hulls thick: COQUE_3D (QUAD9 and TRIA7).

The same reference solution is treated with three forms of loadings: pressure, gravity and force - hull. The sizes observed are: generalized displacements (translation/rotation), deformations and efforts.

1 Problem of reference

1.1 Geometry





1/4 de plaque

Rayon R = 1 m
Epaisseur t = 0.1 m

Coordinates of the points:

	O	A	B	C	D	E	F
x	0.	1.	$1/\sqrt{2}$	0.	0.5	0.	0.4
y	0.	0.	$1/\sqrt{2}$	1.	0.	0.5	0.4
z	0	0.	0.	0.	0.	0.	0.

1.2 Material properties

$E=1\,Pa$	Young modulus
$\nu=0.3$	Poisson's ratio
$\rho=1\,kg/m^3$	Density

1.3 Boundary conditions and loadings

Embedding on the edge of the plate:
in all the points P such as $OP=R$: $u=v=w=0$, $\theta_x=\theta_y=\theta_z=0$.

FORCE_COQUE	Uniform pressure	$P=1\,N/m^2$
FORCE_COQUE	Normal distributed load	$F3=-1\,N/m^2$
GRAVITY	$g=10\,m/s^2$ according to Z from where	$FZ=\rho\,g\,t=-1\,N/m^2$

These three loadings lead to the same solution.

2 Reference solution

2.1 Method of calculating used for the reference solution

Two reference solutions are usable, for the calculation of the deformation:

- the theory of LOVE-KIRCHHOFF, usually used for the plates known as “thin”, that one will retain for modelings With, B, C, D, E and I,
- the theory of MINDLIN-REISSNER, including the effects of shearing for the plates known as “thick”, that one will retain for modelings F, G, H and J.

In any distant point of r center of the plate ($r \leq R$), the arrow is expressed:

$$w(r) = -\frac{P R^4}{64 D}\left(1-\frac{r^2}{R^2}\right)\left(1-\frac{r^2}{R^2}+\varphi\right) \quad \text{avec} \quad D=\frac{E t^3}{12\left(1-\nu^2\right)}$$

avec $\varphi = 0$ (LOVE - KIRCHHOFF) ou $\varphi = \frac{16}{5}\left(\frac{t}{R}\right)^2 \frac{1}{1-\nu}$ (REISSNER).

For the calculation of the moments the two theories lead to the same expressions:

$$M_{rr}(r) = \frac{P R^2}{16}\left((3+\nu)\left(\frac{r}{R}\right)^2-(1+\nu)\right) \quad M_{\theta\theta}(r) = \frac{P R^2}{16}\left((1+3\nu)\left(\frac{r}{R}\right)^2-(1+\nu)\right)$$

In the center of the plate:

$$w(0) = -\frac{P R^4}{64 D} \text{ (LOVE - KIRCHHOFF) ou } w(0) = -\frac{P R^4}{64 D}(1+\varphi) \text{ (REISSNER)}$$

$$M_{rr}(0) = M_{\theta\theta}(0) = -\frac{P R^2}{16}(1+\nu)$$

Note:

Code_Aster calculate the moments with the nodes of each finite element in the reference mark of reference defined by the external normal and the reference axes defined on the hull (see AFFE_CARA_ELEM).

The value of the moment M_{xx} (or M_{yy}) in a node pertaining to several finite elements can be regarded as being the average of the computed values on the elements which have this joint node. This average can be obtained by the procedure POST_RELEVE .

For each node, one a: $\left(M_{rr}+M_{\theta\theta}\right) = \left(M_{xx}+M_{yy}\right) = Sm$

pour le point O	M_{xx}	=	M_{yy}	=	M_{rr}	= $M_{\theta\theta}$
pour les points A et D	M_{xx}	=	M_{rr}	et	M_{yy}	= $M_{\theta\theta}$
pour les points C et E	M_{xx}	=	$M_{\theta\theta}$	et	M_{yy}	= M_{rr}
pour les points B et F	M_{xx}	=	M_{yy}	=	$\left(M_{rr}+M_{\theta\theta}\right)/2$	

2.2 Results of reference

Arrow and moments at the points O, A, B, C, D, E, F. Extraction of the median values of the components M_{xx} et M_{yy} field 'EFGE_ELNO'.

2.3 Uncertainty on the solution

Analytical solution.

2.4 Bibliographical references

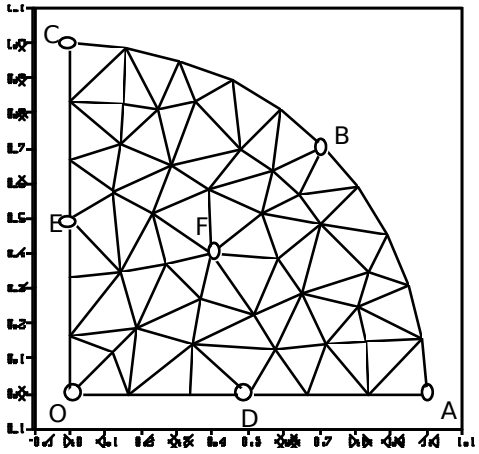
1) TIMOSHENKO and WOINOWSKY-KRIEGER. Plates and hulls. Béranger edition, (1961).

2) BATOZ and DHATT. Modeling of the structures by finite elements. Hulls. Univ presses. Laval, 1992.

3 Modeling A

3.1 Characteristics of modeling

Element of hull DKT (modeling of a quarter of plate)
Number of layer: COQUE_NCOU = 3



Limiting conditions:	DDL_IMPO
in all the nodes of the arc ABC	(GROUP_NO= 'ABC', DX= 0. , DY= 0. , DZ= 0.) DRX=0., DRY=0., DRZ=0.)
in all the nodes of the segment] OA [	(GROUP_NO= 'OA', DY= 0. , DRX=0., DRZ=0.)
in all the nodes of the segment] OC [	(GROUP_NO= 'OC', DX= 0. , DRY=0., DRZ=0.)
with the node O	(GROUP_NO= 'O', DX= 0. , DY= 0. , DRX=0., DRY=0., DRZ=0.)

Not O meshs: M30, M33
Not With meshs: M76
Not B meshs: M39, M40, M51
Not C meshs: M1
Not D meshs: M55, M56, M65
Not E meshs: M8, M17, M18
Not F meshs: M34, M35, M37, M41, M46, M47, M48

3.2 Characteristics of the grid

Many nodes: 50
Many meshs and types: 76 TRIA3

3.3 Sizes tested and results

Identification	Type of reference	Values of reference Coil-Kirchhoff	Tolerance (%)
O $w(r)$	'ANALYTICAL'	– 170.6251	1.0
D $w(r)$	'ANALYTICAL'	– 95.9766	0.75
E $w(r)$	'ANALYTICAL'	– 95.9766	0.75
F $w(r)$	'ANALYTICAL'	– 78,897	0.5

Identification		Type of reference	Values of reference	Tolerance (%)
O	M_{rr}	'ANALYTICAL'	– 0.08125	3.0
	$M_{\theta\theta}$	'ANALYTICAL'	– 0.08125	3.0
With	M_{rr}	'ANALYTICAL'	0,125	2.0
	$M_{\theta\theta}$	'ANALYTICAL'	0.0375	2.0
B	M_{rr}	'ANALYTICAL'	0.08125	5.0
	$M_{\theta\theta}$	'ANALYTICAL'	0.08125	5.0
C	M_{rr}	'ANALYTICAL'	0,125	2.0
	$M_{\theta\theta}$	'ANALYTICAL'	0.0375	2.0
D	M_{rr}	'ANALYTICAL'	– 0.02969	7.0
	$M_{\theta\theta}$	'ANALYTICAL'	– 0.05156	3.5
E	M_{rr}	'ANALYTICAL'	– 0.02969	7.0
	$M_{\theta\theta}$	'ANALYTICAL'	– 0.05156	3.5
F	M_{rr}	'ANALYTICAL'	– 0.02925	3.5
	$M_{\theta\theta}$	'ANALYTICAL'	– 0.02925	4.5

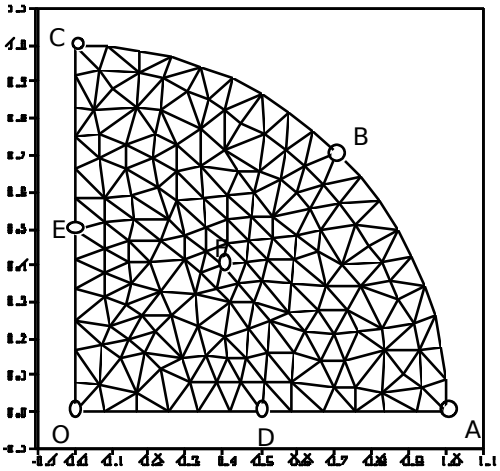
One also tests:

- the continuity of the fields EPSI_ELGA and EPSI_ELNO between the layers (tests of not-regression). Indeed the computed value on level SUP of the layer NR is equal to the computed value on level INF of the N+1 LAYER,
- distribution in volume of the component SIYY (tests of not-regression) of the fields SIEF_ELGA and SIGM_ELNO as well as the volume of the circular plate.

4 Modeling B

4.1 Characteristics of modeling

Element of hull DKT (modeling of a quarter of plate)



Limiting conditions:

		DDL_IMPO
in all the nodes of the arc ABC	(GROUP_NO= 'ABC',	DX= 0. , DY= 0. , DZ= 0. DRX=0., DRY=0., DRZ=0.)
in all the nodes of the segment] OA [	(GROUP_NO= 'OA',	DY= 0. , DRX=0., DRZ=0.)
in all the nodes of the segment] OC [	(GROUP_NO= 'OC',	DX= 0. , DRY=0., DRZ=0.)
with the node O	(GROUP_NO= 'O',	DX= 0. , DY= 0. , DRX=0., DRY=0., DRZ=0.)

Not O meshs: M
Not With
Not B
Not C
Not D
Not E

4.2 Characteristics of the grid

Many nodes: 170
Many meshs and types: 296 TRIA3

4.3 Sizes tested and results

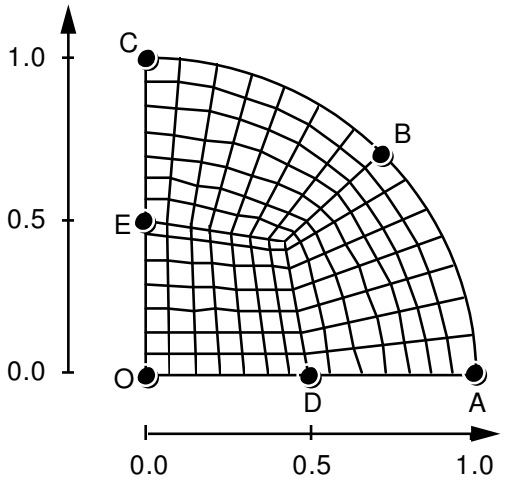
Identification	Type of reference	Values of reference Coil-Kirchhoff	Tolerance (%)
O $w(r)$	'ANALYTICAL'	– 170.6251	0.5
D $w(r)$	'ANALYTICAL'	– 95.9766	0.5
E $w(r)$	'ANALYTICAL'	– 95.9766	0.5
F $w(r)$	'ANALYTICAL'	– 78,897	0.5

Identification		Type of reference	Values of reference	Tolerance (%)
O	M_{rr}	'ANALYTICAL'	– 0.08125	1.0
	$M_{\theta\theta}$	'ANALYTICAL'	– 0.08125	1.0
With	M_{rr}	'ANALYTICAL'	0,125	3.0
	$M_{\theta\theta}$	'ANALYTICAL'	0.0375	9.0
B	M_{rr}	'ANALYTICAL'	0.08125	3.0
	$M_{\theta\theta}$	'ANALYTICAL'	0.08125	3.0
C	M_{rr}	'ANALYTICAL'	0,125	3.0
	$M_{\theta\theta}$	'ANALYTICAL'	0.0375	9.0
D	M_{rr}	'ANALYTICAL'	– 0.02969	2.5
	$M_{\theta\theta}$	'ANALYTICAL'	– 0.05156	2.0
E	M_{rr}	'ANALYTICAL'	– 0.02969	2.5
	$M_{\theta\theta}$	'ANALYTICAL'	– 0.05156	2.5
F	M_{rr}	'ANALYTICAL'	– 0.02925	2.5
	$M_{\theta\theta}$	'ANALYTICAL'	– 0.02925	2.5

5 Modeling E

5.1 Characteristics of modeling

Element of hull DKQ (modeling of a quarter of plate)



Limiting conditions: DDL_IMPO

in all the nodes of the arc ABC	(GROUP_NO= 'ABC', DX= 0. , DY= 0. , DZ= 0.) DRX=0., DRY=0., DRZ=0.)
in all the nodes of the segment] OA [	(GROUP_NO= 'OA', DY= 0. , DRX=0., DRZ=0.)
in all the nodes of the segment] OC [	(GROUP_NO= 'OC', DX= 0. , DRY=0., DRZ=0.)
with the node O	(GROUP_NO= 'O', DX= 0. , DY= 0. , DRX=0., DRY=0., DRZ=0.)

Not O	meshs: M1
Not With	meshs: M147
Not B	meshs: M98 M111
Not C	meshs: M14
Not D	meshs: M85 M99
Not E	meshs: M7 M8
Not F	meshs: M91 M92 M105

5.2 Characteristics of the grid

Many nodes: 169
Many meshs and types: 147 QUAD4

5.3 Sizes tested and results

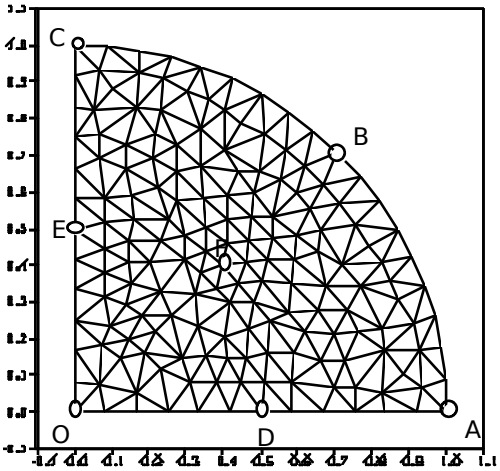
Identification	Type of reference	Values of reference Coil-Kirchhoff	Tolerance (%)
O $w(r)$	'ANALYTICAL'	– 170.6251	0.5
D $w(r)$	'ANALYTICAL'	– 95.9766	0.5
E $w(r)$	'ANALYTICAL'	– 95.9766	0.5
F $w(r)$	'ANALYTICAL'	– 78,897	0.5

Identification		Type of reference	Values of reference	Tolerance (%)
O	M_{rr}	'ANALYTICAL'	– 0.08125	0.5
	$M_{\theta\theta}$	'ANALYTICAL'	– 0.08125	0.5
With	M_{rr}	'ANALYTICAL'	0,125	0.5
	$M_{\theta\theta}$	'ANALYTICAL'	0.0375	0.5
B	M_{rr}	'ANALYTICAL'	0.08125	0.5
	$M_{\theta\theta}$	'ANALYTICAL'	0.08125	0.5
C	M_{rr}	'ANALYTICAL'	0,125	0.5
	$M_{\theta\theta}$	'ANALYTICAL'	0.0375	0.5
D	M_{rr}	'ANALYTICAL'	– 0.02969	2.5
	$M_{\theta\theta}$	'ANALYTICAL'	– 0.05156	3.5
E	M_{rr}	'ANALYTICAL'	– 0.02969	2.5
	$M_{\theta\theta}$	'ANALYTICAL'	– 0.05156	3.5
F	M_{rr}	'ANALYTICAL'	– 0.02925	1.0
	$M_{\theta\theta}$	'ANALYTICAL'	– 0.02925	1.0

6 Modeling F

6.1 Characteristics of modeling

Element of hull DST (modeling of a quarter of plate)



Limiting conditions:		DDL_IMPO
in all the nodes of the arc ABC	(GROUP_NO= 'ABC',	DX= 0. , DY= 0. , DZ= 0.) DRX=0., DRY=0., DRZ=0.)
in all the nodes of the segment] OA [	(GROUP_NO= 'OA',	DY= 0. , DRX=0., DRZ=0.)
in all the nodes of the segment] OC [	(GROUP_NO= 'OC',	DX= 0. , DRY=0., DRZ=0.)
with the node O	(GROUP_NO= 'O',	DX= 0. , DY= 0. , DRX=0., DRY=0., DRZ=0.)

Not O	meshs: M1 M2
Not With	meshs: M248 M255
Not B	meshs: M292 M293 M296
Not C	meshs: M74 M75
Not D	meshs: M76 M108 M109
Not E	meshs: M34 M40 M41
Not F	meshs: M122 M123 M124 M148 M152 M153

6.2 Characteristics of the grid

Many nodes: 170
Many meshs and types: 296 TRIA3

6.3 Sizes tested and results

Identification	Type of reference	Values of reference Reissner	Tolerance (%)
O $w(r)$	'ANALYTICAL'	– 178,419	1.0
D $w(r)$	'ANALYTICAL'	– 101.82	1.0
E $w(r)$	'ANALYTICAL'	– 101.82	1.0
F $w(r)$	'ANALYTICAL'	– 84,198	1.0

Identification		Type of reference	Values of reference	Tolerance (%)
O	M_{rr}	'ANALYTICAL'	– 0.08125	1.5
	$M_{\theta\theta}$	'ANALYTICAL'	– 0.08125	2.0
With	M_{rr}	'ANALYTICAL'	0,125	0.5
	$M_{\theta\theta}$	'ANALYTICAL'	0.0375	23.0
B	M_{rr}	'ANALYTICAL'	0.08125	2.5
	$M_{\theta\theta}$	'ANALYTICAL'	0.08125	2.5
C	M_{rr}	'ANALYTICAL'	0,125	0.5
	$M_{\theta\theta}$	'ANALYTICAL'	0.0375	23.0
D	M_{rr}	'ANALYTICAL'	-0.05156	1.0
	$M_{\theta\theta}$	'ANALYTICAL'	0.0375	5.0
E	M_{rr}	'ANALYTICAL'	– 0.02969	5.0
	$M_{\theta\theta}$	'ANALYTICAL'	– 0.05156	1.0
F	M_{rr}	'ANALYTICAL'	– 0.02925	1.5
	$M_{\theta\theta}$	'ANALYTICAL'	– 0.02925	1.5

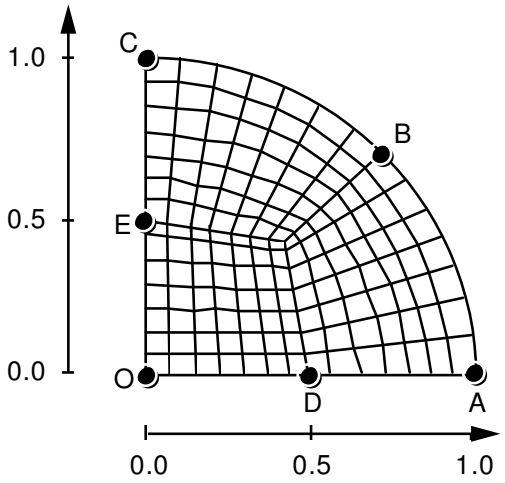
6.4 Contents of the file results

Values at the points of observation of displacements and realised moments.

7 Modeling G

7.1 Characteristics of modeling

Element of hull DSQ (modeling of a quarter of plate)



Limiting conditions:	DDL_IMPO
in all the nodes of the arc ABC	(GROUP_NO= 'ABC', DX= 0. , DY= 0. , DZ= 0.) DRX=0., DRY=0., DRZ=0.)
in all the nodes of the segment] OA [	(GROUP_NO= 'OA', DY= 0. , DRX=0., DRZ=0.)
in all the nodes of the segment] OC [	(GROUP_NO= 'OC', DX= 0. , DRY=0., DRZ=0.)
with the node O	(GROUP_NO= 'O', DX= 0. , DY= 0. , DRX=0., DRY=0., DRZ=0.)

Not O	meshs: M1
Not With	meshs: M147
Not B	meshs: M98 M111
Not C	meshs: M14
Not D	meshs: M85 M99
Not E	meshs: M7 M8
Not F	meshs: M91 M92 M105

7.2 Characteristics of the grid

Many nodes: 169
Many meshs and types: 147 QUAD4

7.3 Sizes tested and results

Identification	Type of reference	Values of reference Reissner	Tolerance (%)
O $w(r)$	'ANALYTICAL'	– 178,419	0.3
D $w(r)$	'ANALYTICAL'	– 101.82	0.3
E $w(r)$	'ANALYTICAL'	– 101.82	0.3
F $w(r)$	'ANALYTICAL'	– 84,198	0.3

Identification		Type of reference	Values of reference	Tolerance (%)
O	M_{rr}	'ANALYTICAL'	– 0.08125	0.5
	$M_{\theta\theta}$	'ANALYTICAL'	– 0.08125	0.5
With	M_{rr}	'ANALYTICAL'	0,125	2.0
	$M_{\theta\theta}$	'ANALYTICAL'	0.0375	11.0
B	M_{rr}	'ANALYTICAL'	0.08125	2.0
	$M_{\theta\theta}$	'ANALYTICAL'	0.08125	2.0
C	M_{rr}	'ANALYTICAL'	0,125	2.0
	$M_{\theta\theta}$	'ANALYTICAL'	0.0375	10.0
D	M_{rr}	'ANALYTICAL'	– 0.02969	2.5
	$M_{\theta\theta}$	'ANALYTICAL'	-0.05156	1.5
E	M_{rr}	'ANALYTICAL'	– 0.02969	2.5
	$M_{\theta\theta}$	'ANALYTICAL'	– 0.05156	1.5
F	M_{rr}	'ANALYTICAL'	– 0.02925	18.0
	$M_{\theta\theta}$	'ANALYTICAL'	– 0.02925	18.0

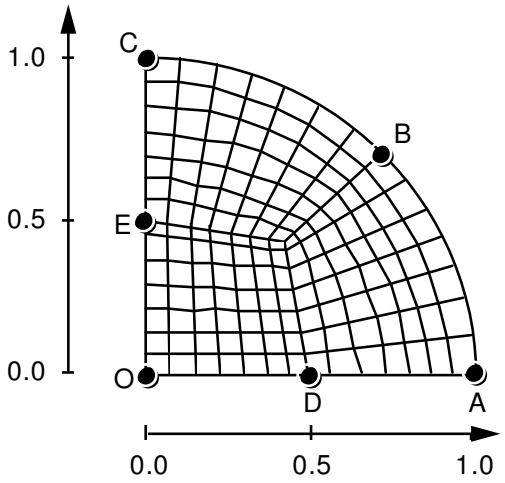
7.4 Contents of the file results

Values at the points of observation of displacements and realised moments.

8 Modeling H

8.1 Characteristics of modeling

Element of hull Q4G (modeling of a quarter of plate)



Limiting conditions: DDL_IMPO

in all the nodes of the arc ABC	(GROUP_NO= 'ABC', DX= 0. , DY= 0. , DZ= 0.) DRX=0., DRY=0., DRZ=0.)
in all the nodes of the segment] OA [	(GROUP_NO= 'OA', DY= 0. , DRX=0., DRZ=0.)
in all the nodes of the segment] OC [	(GROUP_NO= 'OC', DX= 0. , DRY=0., DRZ=0.)
with the node O	(GROUP_NO= 'O" DX= 0. , DY= 0. , DRX=0., DRY=0., DRZ=0.)

Not O	meshs: M1
Not With	meshs: M147
Not B	meshs: M98 M111
Not C	meshs: M14
Not D	meshs: M85 M99
Not E	meshs: M7 M8
Not F	meshs: M91 M92 M105

8.2 Characteristics of the grid

Many nodes: 169
Many meshs and types: 147 QUAD4

8.3 Sizes tested and results

Identification	Type of reference	Values of reference Reissner	Tolerance (%)
O $w(r)$	'ANALYTICAL'	– 178,419	0.4
D $w(r)$	'ANALYTICAL'	– 101.82	0.4
E $w(r)$	'ANALYTICAL'	– 101.82	0.4
F $w(r)$	'ANALYTICAL'	– 84,198	0.4

Identification		Type of reference	Values of reference	Tolerance (%)
O	M_{rr}	'ANALYTICAL'	– 0.08125	0.1
	$M_{\theta\theta}$	'ANALYTICAL'	– 0.08125	0.1
With	M_{rr}	'ANALYTICAL'	0,125	11.0
	$M_{\theta\theta}$	'ANALYTICAL'	0.0375	11.0
B	M_{rr}	'ANALYTICAL'	0.08125	11.0
	$M_{\theta\theta}$	'ANALYTICAL'	0.08125	11.0
C	M_{rr}	'ANALYTICAL'	0,125	11.0
	$M_{\theta\theta}$	'ANALYTICAL'	0.0375	11.0
D	M_{rr}	'ANALYTICAL'	– 0.02969	0.5
	$M_{\theta\theta}$	'ANALYTICAL'	– 0.05156	1.5
E	M_{rr}	'ANALYTICAL'	– 0.02969	0.5
	$M_{\theta\theta}$	'ANALYTICAL'	– 0.05156	1.5
F	M_{rr}	'ANALYTICAL'	– 0.02925	1.0
	$M_{\theta\theta}$	'ANALYTICAL'	– 0.02925	1.0

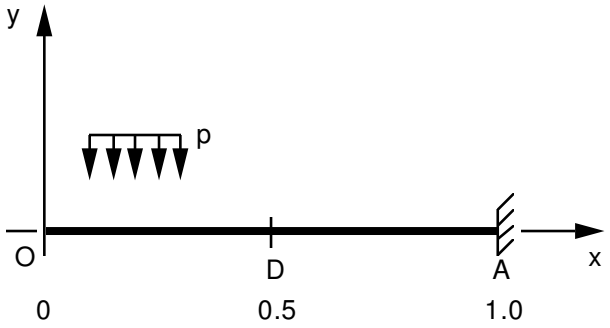
8.4 Contents of the file results

Values at the points of observation of displacements and realised moments.

9 Modeling I

9.1 Characteristics of modeling

Axisymmetric element of hull SEG3, in theory of Coil-Kirchhoff: one does not consider modification of metric, the coefficient A_CIS is worth 10^6.



Limiting conditions:

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DDL_IMPO= (_F
                (NOEUD= 'WITH', DX: 0. , DY: 0. , DRZ: 0.)
                (NOEUD= 'O', DRZ: 0.))
```

9.2 Characteristics of the grid

Many nodes: 21
Many meshs and types: 10 SEG3

9.3 Sizes tested and results

Identification	Type of reference	Values of reference Coil-Kirchhoff	Tolerance (%)
O arrow $w(r)$	'ANALYTICAL'	– 170.6251	0.6
D arrow $w(r)$	'ANALYTICAL'	– 95.9765	1.0
D rotation $\beta(r)$	'ANALYTICAL'	255,940	0.6

Identification			Type of reference	Values of reference	Tolerance (%)
Not	Mesh	Component			
D	IJK	K^{rr}	'ANALYTICAL'	170,625	66.
		$K^{\theta\theta}$	'ANALYTICAL'	511,875	0.5
	KLM	K^{rr}	'ANALYTICAL'	170,625	60
		$K^{\theta\theta}$	'ANALYTICAL'	511,875	0.5

Identification			Type of reference	Values of reference	Tolerance (%)
Not	Mesh	Component			
O	STU	M^{rr}	'ANALYTICAL'	– 0.08125	0.5
		$M^{\theta\theta}$	'ANALYTICAL'	– 0.08125	0.5
With	ABC	M^{rr}	'ANALYTICAL'	0,125	15.0
		$M^{\theta\theta}$	'ANALYTICAL'	0.0375	15.0
D	IJK	$M^{\theta\theta}$	'ANALYTICAL'	– 0.05156	6.0
	KLM	$M^{\theta\theta}$	'ANALYTICAL'	– 0.05156	6.0

Note:

One notes the good performances obtained, except on K^{rr} and M^{rr} , which utilizes derivative of a higher nature less better calculated by the element.

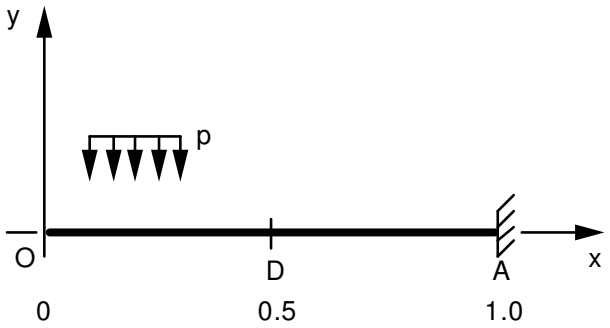
9.4 Contents of the file results

Generalized displacements, deformations and efforts and constraints with the nodes.

10 Modeling J

10.1 Characteristics of modeling

Axisymmetric element of hull SEG3, in theory of Mindlin-Reissner: one does not consider modification of metric, the coefficient A_CIS is worth $5/6$.



Limiting conditions:

```
DDL_IMPO= (_F
            (NOEUD= 'WITH',   DX= 0. , DY= 0. , DRZ= 0.)
            (NOEUD= 'O',                                DRZ= 0.))
```

10.2 Characteristics of the grid

Many nodes: 21
Many meshs and types: 10 SEG3

10.3 Sizes tested and results

Identification	Type of reference	Values of reference Coil-Kirchhoff	Tolerance (%)
O arrow $w(r)$	'ANALYTICAL'	– 178,424	0.5
D arrow $w(r)$	'ANALYTICAL'	– 101,827	0.5
D rotation $\beta(r)$	'ANALYTICAL'	255,940	0.5

Identification			Type of reference	Values of reference	Tolerance (%)
Not	Mesh	Component			
D	IJK	K^{rr}	'ANALYTICAL'	170,625	5.
		$K^{\theta\theta}$	'ANALYTICAL'	511,875	0.5
	KLM	K^{rr}	'ANALYTICAL'	170,625	5.
		$K^{\theta\theta}$	'ANALYTICAL'	511,875	0.5

Identification			Type of reference	Values of reference	Tolerance (%)
Not	Mesh	Component			
O	STU	M^{rr}	'ANALYTICAL'	– 0.08125	1.
		$M^{\theta\theta}$	'ANALYTICAL'	– 0.08125	1.
With	ABC	M^{rr}	'ANALYTICAL'	0,125	2.
		$M^{\theta\theta}$	'ANALYTICAL'	0.0375	2.
With	IJK	$M^{\theta\theta}$	'ANALYTICAL'	– 0.05156	0.5
	KLM	$M^{\theta\theta}$	'ANALYTICAL'	– 0.05156	0.7

Note:

One notes the good performances obtained, except on K^{rr} and M^{rr} , which utilizes derivative of a higher nature less better calculated by the element.

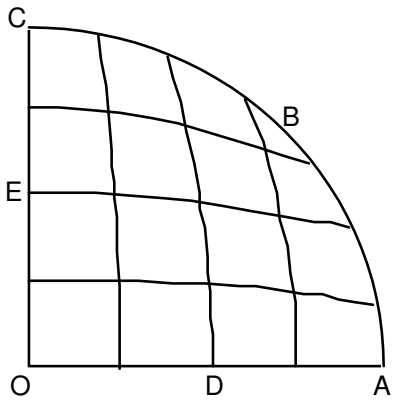
10.4 Contents of the file results

Generalized displacements, deformations and efforts and constraints with the nodes.

11 Modeling K

11.1 Characteristics of modeling

Modeling: Element of hull COQUE_3D MEC3QU9H
Number of layer: COQUE_NCOU = 3



Limiting conditions:

	DDL_IMPO
in all the nodes of the arc ABC	(GROUP_NO= 'ABC', DX= 0. , DY= 0. , DZ= 0.) DRX=0., DRY=0., DRZ=0.)
segment $]OA]$	(GROUP_NO= 'OA', DY= 0. , DRX=0., DRZ=0.)
segment $]OC]$	(GROUP_NO= 'OC', DX= 0. , DRY=0., DRZ=0.)
with the node O	(GROUP_NO= 'O', DX= 0. , DY= 0. , DRX=0., DRY=0., DRZ=0.)

Names of the nodes:

Not 0	meshs: M1	Not With	meshs: M21
Not B	meshs: M25	Not C	meshs: M5
Not D	meshs: M11	Not E	meshs: M3

11.2 Characteristics of the grid

Many nodes: 96
Many meshs and types: 25 QUAD9

11.3 Sizes tested and results

Identification	Type of reference	Values of reference REISSNER	Tolerance (%)
O arrow $w(r)$	'ANALYTICAL'	– 178,419	0.5
D arrow $w(r)$	'ANALYTICAL'	– 101.82	0.5
E arrow $w(r)$	'ANALYTICAL'	– 101.82	0.5

Identification		Type of reference	Values of reference	Tolerance (%)
O	M^{rr}	'ANALYTICAL'	– 0.08125	2.9
	$M^{\theta\theta}$	'ANALYTICAL'	– 0.08125	2.9
With	M^{rr}	'ANALYTICAL'	0,125	2.0
	$M^{\theta\theta}$	'ANALYTICAL'	0.0375	2.0
C	M^{rr}	'ANALYTICAL'	+0,125	1.0
	$M^{\theta\theta}$	'ANALYTICAL'	+0.0375	5.0
D	M^{rr}	'ANALYTICAL'	– 0.02969	1.0
	$M^{\theta\theta}$	'ANALYTICAL'	– 0.05156	2.0
E	M^{rr}	'ANALYTICAL'	– 0.02969	1.0
	$M^{\theta\theta}$	'ANALYTICAL'	– 0.05156	2.0

Note:

The test of the values is carried out automatically using the features offered by the procedure POST_RELEVE :

- *extraction on the nodes corresponding to the points observed of the median values of the components M_{xx} and M_{yy} ; these values are extracted from the field 'EFGE_ELNO' , and the average is calculated for all the liquid assets on the meshs which contain the node observed,*
- *calculation of the variation compared to the value of reference provided by observing the rules of correspondence enters M_{xx} , M_{yy} and M_{rr} , $M_{\theta\theta}$ data page 3.*

Contents of the file results

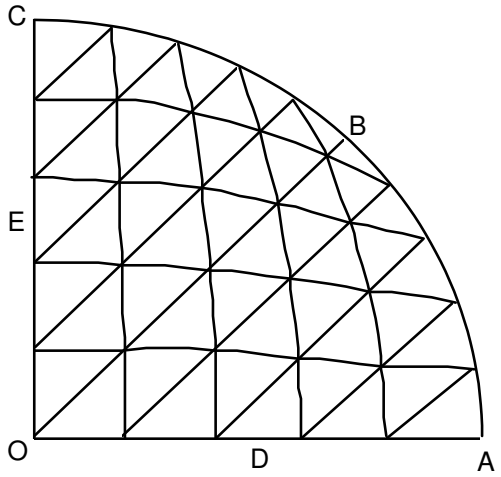
Values at the points of observation of displacements and realised moments.

The continuity of the fields is also tested EPSI_ELGA and EPSI_ELNO between the layers (tests of not-regression). Indeed the computed value on level SUP of the layer NR is equal to the computed value on level INF of the N+1 LAYER.

12 Modeling L

12.1 Characteristics of modeling

Modeling: Element of COQUE_3D MEC3TR7H
Number of layer: COQUE_NCOU = 3



Limiting conditions:

	DDL_IMPO
in all the nodes of the arc ABC	(GROUP_NO= 'ABC', DX= 0. , DY= 0. , DZ= 0.) DRX=0., DRY=0., DRZ=0.)
segment] OA]	(GROUP_NO= 'OA', DY= 0. , DRX=0., DRZ=0.)
segment] OC]	(GROUP_NO= 'OC', DX= 0. , DRY=0., DRZ=0.)
with the node O	(GROUP_NO= 'O' DX= 0. , DY= 0. , DRX=0., DRY=0., DRZ=0.)

Names of the nodes:

Not 0	meshs: M1 and M2	Not With	meshs: M41
Not B	meshs: M49 and M50	Not C	meshs: M10
Not D	meshs: M21	Not E	meshs: M6

12.2 Characteristics of the grid

Many nodes: 121
Many meshs and types: 50 TRIA7

12.3 Sizes tested and results

Identification	Type of reference	Values of reference REISSNER	Tolerance (%)
O arrow $w(r)$	'ANALYTICAL'	– 178,419	0.5
D arrow $w(r)$	'ANALYTICAL'	– 101.82	0.5
E arrow $w(r)$	'ANALYTICAL'	– 101.82	0.5

Identification		Type of reference	Values of reference	Tolerance (%)
O	M^{rr}	'ANALYTICAL'	– 0.08125	2.9
	$M^{\theta\theta}$	'ANALYTICAL'	– 0.08125	2.9
With	M^{rr}	'ANALYTICAL'	0,125	1.7
	$M^{\theta\theta}$	'ANALYTICAL'	0.0375	0.3
C	M^{rr}	'ANALYTICAL'	+0,125	2.0
	$M^{\theta\theta}$	'ANALYTICAL'	+0.0375	2.0
D	M^{rr}	'ANALYTICAL'	– 0.02969	3.0
	$M^{\theta\theta}$	'ANALYTICAL'	– 0.05156	1.0
E	M^{rr}	'ANALYTICAL'	– 0.02969	3.0
	$M^{\theta\theta}$	'ANALYTICAL'	– 0.05156	1.0

Note:

The test of the values is carried out automatically using the features offered by the procedure POST_RELEVE :

- *extraction on the nodes corresponding to the points observed of the median values of the components M_{xx} and M_{yy} ; these values are extracted from the field 'EFGE_ELNO' , and the average is calculated for all the liquid assets on the meshs which contain the node observed,*
- *calculation of the variation compared to the value of reference provided by observing the rules of correspondence enters M_{xx} , M_{yy} and M_{rr} , $M_{\theta\theta}$ data page 3.*

Contents of the file results

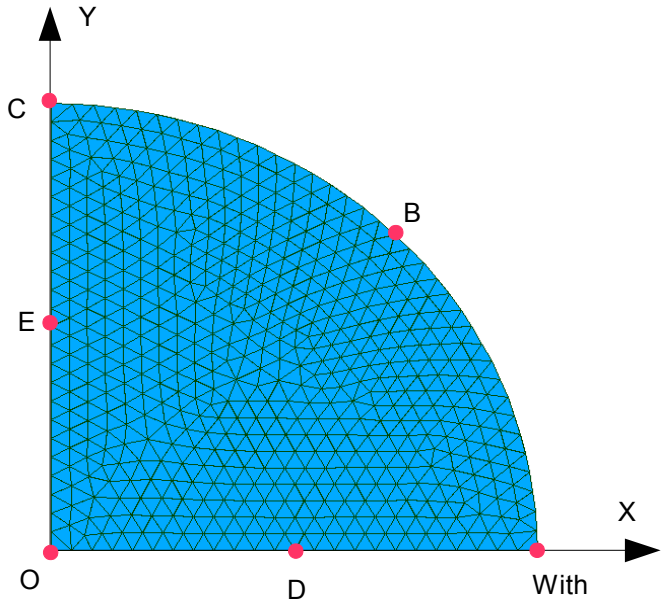
Values at the points of observation of displacements and realised moments.

The continuity of the fields is also tested EPSI_ELGA and EPSI_ELNO between the layers (tests of not-regression). Indeed the computed value on level SUP of the layer NR is equal to the computed value on level INF of the N+1 LAYER.

13 Modeling M

13.1 Characteristics of modeling

Element of hull T3G (modeling of a quarter of plate)



Limiting conditions:

	DDL_IMPO
in all the nodes of the arc ABC	(GROUP_NO= 'ABC', DX= 0. , DY= 0. , DZ= 0. DRX=0., DRY=0., DRZ=0.)
in all the nodes of the segment] OA [	(GROUP_NO= 'OA', DY= 0. , DRX=0., DRZ=0.)
in all the nodes of the segment] OC [	(GROUP_NO= 'OC', DX= 0. , DRY=0., DRZ=0.)
with the node O	(GROUP_NO= 'O', DX= 0. , DY= 0. , DRX=0., DRY=0., DRZ=0.)

Not O	meshs: M31
Not With	meshs: M19
Not B	meshs: M10 M100 M54
Not C	meshs: M1
Not D	meshs: M71 M113 M25
Not E	meshs: M37 M123 M86

13.2 Characteristics of the grid

Many nodes: 561
Many meshs and types: 1036 TRIA3

13.3 Sizes tested and results

Identification	Type of reference	Values of reference Reissner	Tolerance (%)
O $w(r)$	'ANALYTICAL'	– 178,419	0.5
D $w(r)$	'ANALYTICAL'	– 101.82	1.0
E $w(r)$	'ANALYTICAL'	– 101.82	1.0

Identification		Type of reference	Values of reference	Tolerance (%)
O	M_{rr}	'ANALYTICAL'	– 0.08125	1.0
	$M_{\theta\theta}$	'ANALYTICAL'	– 0.08125	1.0
With	M_{rr}	'ANALYTICAL'	0,125	7.0
	$M_{\theta\theta}$	'ANALYTICAL'	0.0375	7.0
B	M_{rr}	'ANALYTICAL'	0.08125	8.0
	$M_{\theta\theta}$	'ANALYTICAL'	0.08125	8.0
C	M_{rr}	'ANALYTICAL'	0,125	6.0
	$M_{\theta\theta}$	'ANALYTICAL'	0.0375	6.5
D	M_{rr}	'ANALYTICAL'	– 0.02969	1.0
	$M_{\theta\theta}$	'ANALYTICAL'	– 0.05156	0.5
E	M_{rr}	'ANALYTICAL'	– 0.02969	0.5
	$M_{\theta\theta}$	'ANALYTICAL'	– 0.05156	1.

14 Summary of the results

% of the differences compared to the reference solutions

Mode.	DKT With Coil	B Kirchhoff	DKQ E Coil-Kirchhoff	DST F Reissner	DSQ G Reissner	Q4G H Reissner
Not	50 nodes 76 TRIA3	170 nodes 296 TRIA3	169 nodes 147 QUAD4	170 nodes 296 TRIA3	169 nodes 147 QUAD4	169 nodes 147 QUAD4
O $w(r)$	– 0.76	+0.12	+0.22	+0.74	+0.19	– 0.08
D $w(r)$	– 0.23	+0.18	+0.23	+0.77	+0.19	– 0.28
E $w(r)$	– 0.25	+0.24	+0.23	+0.84	+0.19	– 0.28
F $w(r)$	– 0.32	+0.22	+0.20	+0.75	+0.14	– 0.34

Mode.	Q4G M Reissner
Not	561 nodes - 1036 TRIA3
O $w(r)$	+0,176
D $w(r)$	+0,225
E $w(r)$	+0,225
F $w(r)$	-

Mode.	COQU_AXIS I Coil-Kirchhoff	J Reissner	MEC3QU9H K	MEC3TR7H L
Not	21 nodes 10 SEG3		96 nodes 25 QUAD9	121 nodes 50 TRIA7
O $w(r)$	+0.51	0.03	– 0.16	– 0.13
D $w(r)$	+0.28	0.05	– 0,029	– 0.35
E $w(r)$	-	-	– 0,029	– 0.35
F $w(r)$	-	+0.22	-	-

Mode.	DKT With Coil	B Kirchhoff	DKQ E Coil-Kirchhoff	DST F Reissner	DSQ G Reissner	Q4G H Reissner
Not	50 nodes 76 TRIA3	170 nodes 296 TRIA3	169 nodes 147 QUAD4	170 nodes 296 TRIA3	169 nodes 147 QUAD4	169 nodes 147 QUAD4
O $Sm/2$	– 1.15	+0.19	+0.46	+1.04	– 0.33	– 0.07
With $Sm/2$	+0.81	+4.02	+0.49	+5.26	+3.79	– 10.73
B $Sm/2$	+4.58	+2.64	+0.20	+2.02	+1.69	– 10.95
C $Sm/2$	+0.75	+4.13	+0.45	+5.34	+3.64	– 10.69
D $Sm/2$	+4.55	+1.99	+2.71	+2.07	+0.40	+0.74
E $Sm/2$	+4.55	+2.19	+2.71	+2.29	+0.40	+0.74
F $Sm/2$	+1.71	+2.05	– 0.79	+1.19	+17.80	– 0.94

Mode.	Q4G M Reissner
Not	561 nodes - 1036 TRIA3
O $Sm/2$	+0,265
With $Sm/2$	+1.65
B $Sm/2$	+4.95
C $Sm/2$	+1.73
D $Sm/2$	+5.18
E $Sm/2$	+5.50
F $Sm/2$	+4.07

Mode.	COQU_AXIS I Coil-Kirchhoff	COQU_AXIS J Reissner	MEC3QU9H K	MEC3TR7H L
Not	21 nodes 10 SEG3		96 nodes 25 QUAD9	121 nodes 50 TRIA7
O $Sm/2$	+0.18	+0.62	2.67	2.89
With $Sm/2$	+14.2	– 1.01	– 1.45	– 1.33
B $Sm/2$	-	-	-	-
C $Sm/2$	-	-	– 1.46	– 1.32
D $Sm/2$	+0.84	– 0.85	1.08	– 1.23
E $Sm/2$	-	-	0.95	– 1.23
F $Sm/2$	-	-	-	-

Note:

Concerning the efforts, direct calculation with the nodes leads to variations in several nodes, in particular at the point F in DSQ and on the edge ABC in Q4G .