

SSLS114 - Not regression on cylindrical quarter of binding ring

Summary:

It is about a test of mechanics in linear statics.

The goal is to test the setting under pressure of a cylindrical quarter of binding ring with the elements of hull and plate.

1 Problem of reference

1.1 Properties of materials

$$E = 200\,000 \text{ MPa}$$

$$\nu = 0.3$$

$$\rho = 1234. \text{ kg/m}^3 \text{ for modelings } I.$$

1.2 Geometrical characteristics

One notes:

- 1) $R_1 = 0.975 \text{ m}$ the interior ray of the cylinder;
- 2) $R_2 = 1.025 \text{ m}$ the ray external of the cylinder;
- 3) $R = 1 \text{ m}$ the average radius of the cylinder equal to the half the sum of the two preceding rays;
- 4) $e = 0.05 \text{ m}$ the radial thickness of the cylinder;
- 5) $h = 0.5 \text{ m}$ the height of the cylinder.

1.3 Boundary conditions and loadings mechanical

Conditions of Dirichlet

DDL_IMPO, the blocked nodes depend on modeling.

pressure on the elements of hull and plate: $P = 10 \text{ MPa}$ on the cylinder

PRES_REP

FORCE_COQUE (real or given by a function)

2 Reference solution

Analytical solution.

2.1 Results of reference

Displacement of the average layer

Constraints of the average layer, layers superior and inferior.

In modeling I one calculates the mass, the coordinates of the centre of gravity and the terms of the matrix of inertia. The analytical expressions are given in documentation [R3.07.02].

2.1.1 Method of calculating used for the reference solution in displacements and constraints

Into incompressible:

$$\begin{cases} u_r \\ u_\theta \\ u_z \end{cases} = \begin{cases} \frac{B}{r} \\ 0 \\ 0 \end{cases} \quad \text{avec } B = \frac{(1+\nu) P}{E} \frac{a^2 b^2}{(b^2 - a^2)}$$

$$\begin{cases} \varepsilon_{rr} \\ \varepsilon_{\theta\theta} \\ \varepsilon_{r\theta} \\ \varepsilon_{zz} \end{cases} = \begin{cases} -\frac{B}{r^2} \\ +\frac{B}{r^2} \\ 0 \\ 0 \end{cases}$$

$$\begin{cases} J_{rr} \\ J_{\theta\theta} \\ \sigma_{r\theta} \\ \sigma_{zz} \end{cases} = \begin{cases} P \frac{a^2}{b^2 - a^2} \left[1 - \frac{b^2}{r^2} \right] \\ P \frac{a^2}{b^2 - a^2} \left[1 + \frac{b^2}{r^2} \right] \\ 0 \\ 2 \nu P \frac{a^2}{b^2 - a^2} \end{cases}$$

Passage in the Cartesian system:

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

2.1.2 Determination of the masses, centre of gravity and tensor of inertia

For modeling I of standard hull of revolution around an axis OZ

- 1) the mass is worth: $M = \rho h \pi (R_2^2 - R_1^2) = 2\pi \rho h e R$;

- 2) the coordinates of the centre of gravity are: $\begin{pmatrix} x_G \\ y_G \\ z_G \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ h/2 \end{pmatrix}$;

- 3) the tensor of inertia compared to O is worth:

$$\begin{pmatrix} I_{xx} & I_{xy} & I_{xz} \\ I_{xy} & I_{yy} & I_{yz} \\ I_{xz} & I_{yz} & I_{zz} \end{pmatrix} = \begin{pmatrix} \frac{MR^2}{2} \left[1 + \frac{1}{4} \left(\frac{e}{R} \right)^2 \right] + \frac{M}{3} h^2 & 0 & 0 \\ 0 & \frac{MR^2}{2} \left[1 + \frac{1}{4} \left(\frac{e}{R} \right)^2 \right] + \frac{M}{3} h^2 & 0 \\ 0 & 0 & MR^2 \left[1 + \frac{1}{4} \left(\frac{e}{R} \right)^2 \right] \end{pmatrix}$$

- 4) the tensor of inertia compared to G is worth:

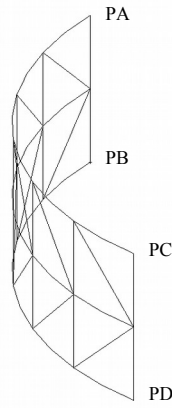
$$\begin{pmatrix} I_{xx} & I_{xy} & I_{xz} \\ I_{xy} & I_{yy} & I_{yz} \\ I_{xz} & I_{yz} & I_{zz} \end{pmatrix} = \begin{pmatrix} \frac{MR^2}{2} \left[1 + \frac{1}{4} \left(\frac{e}{R} \right)^2 \right] + \frac{M}{12} h^2 & 0 & 0 \\ 0 & \frac{MR^2}{2} \left[1 + \frac{1}{4} \left(\frac{e}{R} \right)^2 \right] + \frac{M}{12} h^2 & 0 \\ 0 & 0 & MR^2 \left[1 + \frac{1}{4} \left(\frac{e}{R} \right)^2 \right] \end{pmatrix}$$

Note:

In practice, one neglects the terms in $\left(\frac{e}{R} \right)^2$ in these expressions.

3 Modeling A

3.1 Characteristics of the grid



Coordinates of the points:

GROUP_NO	Coor _x	Coor _y	Coor _z
PA	-1.	0.	5.0E-01
PB	-1.	0.	0.
PC	0.	-1.	5.0E-01
PD	0.	-1.	0.

Characteristics of the elements:

Types of meshes: 24 COQUE_3D
24 TRIA7

Boundary conditions:

Group of meshes *AB* :

- 1) displacement following the axis Y : DY = 0
- 2) rotation around the axis X : DRX = 0
- 3) rotation around the axis Z : DRZ = 0

Group of meshes *CD* :

- 1) displacement following the axis X : DX = 0
- 2) rotation around the axis Y : DRY MARTINI = 0
- 3) rotation around the axis Z : DRZ = 0

Group of nodes *PB* :

- 1) displacement following the axis Z : DZ = 0

with *AB* the group of meshes connecting *PA* and *PB*
and *CD* that connecting *PC* and *PD*

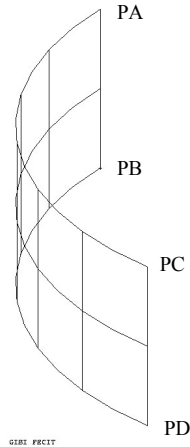
3.2 Sizes tested and results

In a systematic way, one takes the values of displacements and the constraints on the node *PA*

Keyword	Identification	Type of Reference	Value of reference	Tolerance
PRES_REP	Displacements	'ANALYTICAL'	- 9.81907 10 ⁻¹⁰	3.3%
	Average layer			
	Constraints (<i>SIXX</i>)	'ANALYTICAL'	194.93754	0.7%
	Average layer			
Higher layer				
	Lower layer	'ANALYTICAL'	190,125	27.%
FORCE_COQUE (REALITY)	Displacements	'ANALYTICAL'	- 9.81907 10 ⁻¹⁰	3.3%
	Average layer			
	Constraints (<i>SIXX</i>)	'ANALYTICAL'	194.93754	0.7%
	Average layer			
Higher layer				
	Lower layer	'ANALYTICAL'	190,125	27.%
FORCE_COQUE (FUNCTION)	Displacements	'ANALYTICAL'	- 9.81907 10 ⁻¹⁰	3.3%
	Average layer			
	Constraints (<i>SIXX</i>)	'ANALYTICAL'	194.93754	0.7
	Average layer			
Higher layer				
	Lower layer	'ANALYTICAL'	190,125	27.%

4 Modeling B

4.1 Characteristics of the grid



Coordinates of the points:

GROUP_NO	Coord _x	Coord _y	Coord _z
PA	-1.	0.	5.0E-01
PB	-1.	0.	0.
PC	0.	-1.	5.0E-01
PD	0.	-1.	0.

Characteristics of the elements:

Types of meshes: 12 COQUE_3D
 12 QUAD9

Boundary conditions:

Group of meshes *AB* :

- 1) displacement following the axis Y : DY = 0
- 2) rotation around the axis X : DRX = 0
- 3) rotation around the axis Z : DRZ = 0

Group of meshes *CD* :

- 1) displacement following the axis X : DX = 0
- 2) rotation around the axis Y : DRY MARTINI = 0
- 3) rotation around the axis Z : DRZ = 0

Group of nodes *PB* :

- 1) displacement following the axis Z : DZ = 0

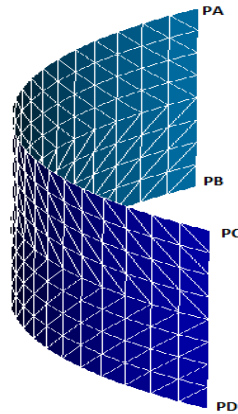
with *AB* the group of meshes connecting *PA* and *PB*
and *CD* that connecting *PC* and *PD*

4.2 Sizes tested and results

Keyword	Identification	Type of Reference	Value of reference	Tolerance
PRES_REP	Displacements Average layer	'ANALYTICAL'	$- 9.81907 \cdot 10^{-10}$	1.5%
	Constraints (<i>SIXX</i>)			
	Average layer	'ANALYTICAL'	194.93754	2.3%
	Higher layer	'ANALYTICAL'	200,125	2.2%
	Lower layer	'ANALYTICAL'	190,125	2.3%
FORCE_COQUE (REALITY)	Displacements Average layer	'ANALYTICAL'	$- 9.81907 \cdot 10^{-10}$	1.5%
	Constraints (<i>SIXX</i>)			
	Average layer	'ANALYTICAL'	194.93754	2.3%
	Higher layer	'ANALYTICAL'	200,125	2.2%
	Lower layer	'ANALYTICAL'	190,125	2.3%
FORCE_COQUE (FUNCTION)	Displacements Average layer	'ANALYTICAL'	$- 9.81907 \cdot 10^{-10}$	1.5%
	Constraints (<i>SIXX</i>)			
	Average layer	'ANALYTICAL'	194.93754	2.3%
	Higher layer	'ANALYTICAL'	200,125	2.2%
	Lower layer	'ANALYTICAL'	190,125	2.3%

5 Modeling C

5.1 Characteristics of the grid



Coordinates of the points:

GROUP_NO	$Coor_x$	$Coor_y$	$Coor_z$
<i>PA</i>	-1.	0.	5.0E-01
<i>PB</i>	-1.	0.	0.
<i>PC</i>	0.	-1.	5.0E-01
<i>PD</i>	0.	-1.	0.

Characteristics of the elements:

Types of meshes: 192 DKT
 192 DST

Boundary conditions:

Group of meshes *AB* :

- 1) displacement following the axis Y : $DY = 0$
- 2) rotation around the axis X : $DRX = 0$
- 3) rotation around the axis Z : $DRZ = 0$

Group of meshes *CD* :

- 1) displacement following the axis X : $DX = 0$
- 2) rotation around the axis Y : $DRY \text{ MARTINI} = 0$
- 3) rotation around the axis Z : $DRZ = 0$

Group of nodes *PB* :

- 1) displacement following the axis Z : $DZ = 0$

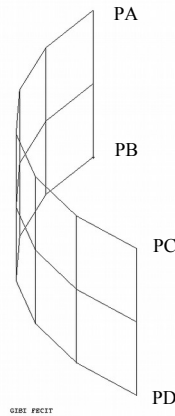
with *AB* the group of meshes connecting *PA* and *PB*
and *CD* that connecting *PC* and *PD*

5.2 Sizes tested and results

Keyword	Identification	Type of Reference	Value of reference	Tolerance
PRES_REP	Displacements Average layer	'ANALYTICAL'	$-9.81907 \cdot 10^{-10}$	2.0%
	Constraints (<i>SIXX</i>)			
	Average layer	'ANALYTICAL'	194.93754	3.0%
	Higher layer	'ANALYTICAL'	200,125	5.5%
	Lower layer	'ANALYTICAL'	190,125	3.0%
FORCE_COQUE (REALITY)	Displacements Average layer	'ANALYTICAL'	$-9.81907 \cdot 10^{-10}$	2.0%
	Constraints (<i>SIXX</i>)			
	Average layer	'ANALYTICAL'	194.93754	3.0%
	Higher layer	'ANALYTICAL'	200,125	5.5%
	Lower layer	'ANALYTICAL'	190,125	3.0%
FORCE_COQUE (FUNCTION)	Displacements Average layer	'ANALYTICAL'	$-9.81907 \cdot 10^{-10}$	2.0%
	Constraints (<i>SIXX</i>)			
	Average layer	'ANALYTICAL'	194.93754	3.0%
	Higher layer	'ANALYTICAL'	200,125	5.5%
	Lower layer	'ANALYTICAL'	190,125	3.0%

6 Modeling D

6.1 Characteristics of the grid



Coordinates of the points:

GROUP_NO	Coor _x	Coor _y	Coor _z
PA	-1.	0.	5.0E-01
PB	-1.	0.	0.
PC	0.	-1.	5.0E-01
PD	0.	-1.	0.

Characteristics of the elements:

Types of meshes: 6 DKQ
 6 DSQ

Boundary conditions:

Group of meshes *AB* :

- 1) displacement following the axis Y : DY = 0
- 2) rotation around the axis X : DRX = 0
- 3) rotation around the axis Z : DRZ = 0

Group of meshes *CD* :

- 1) displacement following the axis X : DX = 0
- 2) rotation around the axis Y : DRY MARTINI = 0
- 3) rotation around the axis Z : DRZ = 0

Group of nodes *PB* :

- 1) displacement following the axis Z : DZ = 0

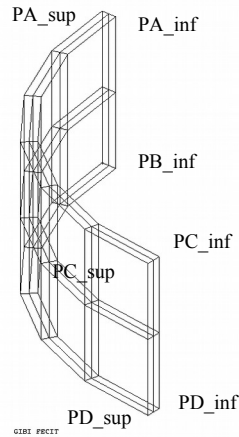
with *AB* the group of meshes connecting *PA* and *PB*
and *CD* that connecting *PC* and *PD*

6.2 Sizes tested and results

Keyword	Identification	Type of Reference	Value of reference	Tolerance
PRES_REP	Displacements Average layer	'ANALYTICAL'	$-9.81907 \cdot 10^{-10}$	1.0%
	Constraints (<i>SIXX</i>) Average layer	'ANALYTICAL'	194.93754	1.8%
	Higher layer	'ANALYTICAL'	200,125	1.0%
	Lower layer	'ANALYTICAL'	190,125	4.3%
FORCE_COQUE (REALITY)	Displacements Average layer	'ANALYTICAL'	$-9.81907 \cdot 10^{-10}$	1.0%
	Constraints (<i>SIXX</i>) Average layer	'ANALYTICAL'	194.93754	1.8%
	Higher layer	'ANALYTICAL'	200,125	1.0%
	Lower layer	'ANALYTICAL'	190,125	4.3%
FORCE_COQUE (FUNCTION)	Displacements Average layer	'ANALYTICAL'	$-9.81907 \cdot 10^{-10}$	1.0%
	Constraints (<i>SIXX</i>) Average layer	'ANALYTICAL'	194.93754	1.8%
	Higher layer	'ANALYTICAL'	200,125	1.0%
	Lower layer	'ANALYTICAL'	190,125	4.3%

7 Modeling E

7.1 Characteristics of the grid



Coordinates of the points:

GROUP_NO	Coor _x	Coor _y	Coor _z
PA_inf	-9.75E-01	0.	5.0E-01
Pa	-1.	0.	5.0E-01
PA_sup	-1.025E+00	0.	5.0E-01
PB_inf	-9.75E-01	0.	0.
PB	-1.	0.	0.
PB_sup	-1.025E+00	0.	0.
PC_inf	0.	-9.75E-01	5.0E-01
PC	0.	-1.	5.0E-01
PC_sup	0.	-1.025E+00	5.0E-01
PD_inf	0.	-9.75E-01	0.
PD	0.	-1.	0.
PD_sup	0.	-1.025E+00	0.

Characteristics of the elements:

Types of meshes: 24 meshes HEXA8 3D linear

Boundary conditions:

Group of meshes S_AB :

- 1) displacement following the axis Y : DY = 0
- 2) displacement following the axis Z : DZ = 0

Group of meshes S_CD :

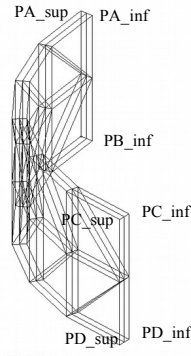
- 1) displacement following the axis X : DX = 0
- 2) displacement following the axis Z : DZ = 0

7.2 Sizes tested and results

Keyword	Identification	Type of Reference	Value of reference	Tolerance
PRES_REP (REALITY)	Displacements			
	Average layer	'ANALYTICAL'	-9.81907 10 ⁻¹⁰	1.6%
	Lower layer	'ANALYTICAL'	-9.90234 10 ⁻¹⁰	1.3%
	Higher layer	'ANALYTICAL'	-9.81907 10 ⁻¹⁰	2.6%
	Constraints (SIYY)			
	Average layer	'ANALYTICAL'	194,93754	8.3%
	Lower layer	'ANALYTICAL'	200,125	9%
Higher layer	'ANALYTICAL'	190,125	8%	
PRES_REP (FUNCTION)	Displacements			
	Average layer	'ANALYTICAL'	-9.81907 10 ⁻¹⁰	1.6%
	Lower layer	'ANALYTICAL'	-9.90234 10 ⁻¹⁰	1.3%
	Higher layer	'ANALYTICAL'	-9.81907 10 ⁻¹⁰	2.6%
	Constraints (SIYY)			
	Average layer	'ANALYTICAL'	194,93754	8.3%
	Lower layer	'ANALYTICAL'	200,125	9%
Higher layer	'ANALYTICAL'	190,125	8%	

8 Modeling F

8.1 Characteristics of the grid



Coordinates of the points:

GROUP_NO	Coor _x	Coor _y	Coor _z
PA_inf	-9.75E-01	0.	5.0E-01
Pa	-1.	0.	5.0E-01
PA_sup	-1.025E+00	0.	5.0E-01
PB_inf	-9.75E-01	0.	0.
PB	-1.	0.	0.
PB_sup	-1.025E+00	0.	0.
PC_inf	0.	-9.75E-01	5.0E-01
PC	0.	-1.	5.0E-01
PC_sup	0.	-1.025E+00	5.0E-01
PD_inf	0.	-9.75E-01	0.
PD	0.	-1.	0.
PD_sup	0.	-1.025E+00	0.

Characteristics of the elements:

Types of meshes: 48 meshes PENTA6 3D linear

Boundary conditions:

Group of meshes S_AB :

- 1) displacement following the axis Y : DY = 0
- 2) displacement following the axis Z : DZ = 0

Group of meshes S_CD :

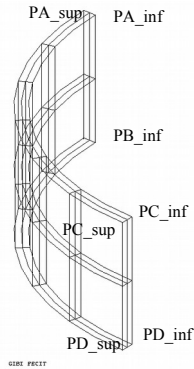
- 1) displacement following the axis X : DX = 0
- 2) displacement following the axis Z : DZ = 0

8.2 Sizes tested and results

Keyword	Identification	Type of Reference	Value of reference	Tolerance
PRES_REP (REALITY)	Displacements			
	Average layer	'ANALYTICAL'	-9.81907 10 ⁻¹⁰	1.7%
	Lower layer	'ANALYTICAL'	-9.90234 10 ⁻¹⁰	1.2%
	Higher layer	'ANALYTICAL'	-9.81907 10 ⁻¹⁰	2.8%
	Constraints (SIYY)			
	Average layer	'ANALYTICAL'	194,93754	10%
PRES_REP (FUNCTION)	Displacements			
	Average layer	'ANALYTICAL'	-9.81907 10 ⁻¹⁰	1.7%
	Lower layer	'ANALYTICAL'	-9.90234 10 ⁻¹⁰	1.2%
	Higher layer	'ANALYTICAL'	-9.81907 10 ⁻¹⁰	2.8%
	Constraints (SIYY)			
	Average layer	'ANALYTICAL'	194,93754	10%
	Lower layer	'ANALYTICAL'	200,125	21%
	Higher layer	'ANALYTICAL'	190,125	2.1%

9 Modeling G

9.1 Characteristics of the grid



Coordinates of the points:

GROUP_NO	Coor _x	Coor _y	Coor _z
PA_inf	-9.75E-01	0.	5.0E-01
Pa	-1.	0.	5.0E-01
PA_sup	-1.025E+00	0.	5.0E-01
PB_inf	-9.75E-01	0.	0.
PB	-1.	0.	0.
PB_sup	-1.025E+00	0.	0.
PC_inf	0.	-9.75E-01	5.0E-01
PC	0.	-1.	5.0E-01
PC_sup	0.	-1.025E+00	5.0E-01
PD_inf	0.	-9.75E-01	0.
PD	0.	-1.	0.
PD_sup	0.	-1.025E+00	0.

Characteristics of the elements:

Types of meshes: 24 meshes HEXA20 3D quadratic

Boundary conditions:

Group of meshes S_AB :

- 1) displacement following the axis Y : DY = 0
- 2) displacement following the axis Z : DZ = 0

Group of meshes S_CD :

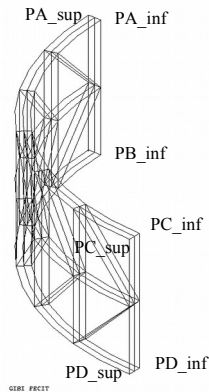
- 1) displacement following the axis X : DX = 0
- 2) displacement following the axis Z : DZ = 0

9.2 Sizes tested and results

Keyword	Identification	Type of Reference	Value of reference	Tolerance
PRES_REP (REALITY)	Displacements			
	Average layer	'ANALYTICAL'	-9.81907 10 ⁻¹⁰	1.6%
	Lower layer	'ANALYTICAL'	-9.90234 10 ⁻¹⁰	1.2%
	Higher layer	'ANALYTICAL'	-9.81907 10 ⁻¹⁰	2.7%
	Constraints (SIYY)			
	Average layer	'ANALYTICAL'	194,93754	13%
PRES_REP (FUNCTION)	Displacements			
	Average layer	'ANALYTICAL'	-9.81907 10 ⁻¹⁰	1.6%
	Lower layer	'ANALYTICAL'	-9.90234 10 ⁻¹⁰	1.2%
	Higher layer	'ANALYTICAL'	-9.81907 10 ⁻¹⁰	2.7%
	Constraints (SIYY)			
	Average layer	'ANALYTICAL'	194,93754	13%
	Lower layer	'ANALYTICAL'	200,125	13%
	Higher layer	'ANALYTICAL'	190,125	11%

10 Modeling H

10.1 Characteristics of the grid



Coordinates of the points:

GROUP_NO	$Coor_x$	$Coor_y$	$Coor_z$
PA_inf	-9.75E-01	0.	5.0E-01
Pa	-1.	0.	5.0E-01
PA_sup	-1.025E+00	0.	5.0E-01
PB_inf	-9.75E-01	0.	0.
PB	-1.	0.	0.
PB_sup	-1.025E+00	0.	0.
PC_inf	0.	-9.75E-01	5.0E-01
PC	0.	-1.	5.0E-01
PC_sup	0.	-1.025E+00	5.0E-01
PD_inf	0.	-9.75E-01	0.
PD	0.	-1.	0.
PD_sup	0.	-1.025E+00	0.

Characteristics of the elements:

Types of meshes: 48 meshes PENTA15 3D quadratic

Boundary conditions:

Group of meshes S_{AB} :

- 1) displacement following the axis Y : $DY=0$
- 2) displacement following the axis Z : $DZ=0$

Group of meshes S_{CD} :

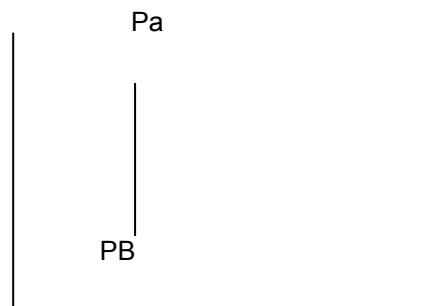
- 1) displacement following the axis X : $DX=0$
- 2) displacement following the axis Z : $DZ=0$

10.2 Sizes tested and results

Keyword	Identification	Type of Reference	Value of reference	Tolerance
PRES_REP (REALITY)	Displacements			
	Average layer	'ANALYTICAL'	-9.81907 10 ⁻¹⁰	1.7%
	Lower layer	'ANALYTICAL'	-9.90234 10 ⁻¹⁰	1.2%
	Higher layer	'ANALYTICAL'	-9.81907 10 ⁻¹⁰	2.8%
	Constraints (SIYY)			
	Average layer	'NON_DEFINI'	194.93754	10.0%
	Lower layer	'NON_DEFINI'	200,125	21.0%
Higher layer	'NON_DEFINI'	190,125	2.1%	
PRES_REP (FUNCTION)	Displacements			
	Average layer	'ANALYTICAL'	-9.81907 10 ⁻¹⁰	1.7%
	Lower layer	'ANALYTICAL'	-9.90234 10 ⁻¹⁰	1.2%
	Higher layer	'ANALYTICAL'	-9.81907 10 ⁻¹⁰	2.8%
	Constraints (SIYY)			
	Average layer	'NON_DEFINI'	194.93754	10.0%
	Lower layer	'NON_DEFINI'	200,125	21.0%
Higher layer	'NON_DEFINI'	190,125	2.1%	

11 Modeling I

11.1 Characteristics of the grid



Coordinates of the points:

GROUP_NO	Coor _x	Coor _y
PA	1.0	0.5
PB	1.0	0.

Characteristics of the elements:

Types of meshes: 2 COQUE_AXI

Thus $R1=1.025\text{ m}$ and $R2=0.975\text{ m}$.
 $h=0.5\text{ m}$

For this modeling and the following ones, one specifies the density $\rho=1234.\text{ kg/m}^3$

Boundary conditions:

Group of nodes PB : displacement following the axis Y : $DY=0$

11.2 Sizes tested and results

Keyword	Identification	Type of Reference	Value of reference	Tolerance
PRES_REP	Displacements Average layer	'ANALYTICAL'	$-9.81907 \cdot 10^{-10}$	2%
	Constraints (SIYY) Average layer	'NON_DEFINI'	194.93754	10%
FORCE_COQUE (REALITY) with MODI_METRIQUE	Displacements Average layer	'ANALYTICAL'	$-9.81907 \cdot 10^{-10}$	2%
	Constraints (SIYY) Average layer	'ANALYTICAL'	194.93754	2.8%
	Higher layer	'ANALYTICAL'	200,125	2.8%
	Lower layer	'ANALYTICAL'	190,125	2.8%
FORCE_COQUE (FUNCTION) with MODI_METRIQUE	Displacements Average layer	'ANALYTICAL'	$-9.81907 \cdot 10^{-10}$	2%
	Constraints (SIYY) Average layer	'ANALYTICAL'	194.93754	2.8%
	Higher layer	'ANALYTICAL'	200,125	2.8%
	Lower layer	'ANALYTICAL'	190,125	2.8%
FORCE_COQUE (FUNCTION) without MODI_METRIQUE	Displacements Average layer	'ANALYTICAL'	$-9.81907 \cdot 10^{-10}$	2%
	Constraints (SIYY) Average layer	'ANALYTICAL'	194.93754	2.8%
	Higher layer	'ANALYTICAL'	200,125	0.1%
	Lower layer	'ANALYTICAL'	190,125	5.2%

Identification	Type of Reference	Value of reference	Tolerance
MASS	'ANALYTICAL'	1.93836 E+02	0.1%
CDG_X	'ANALYTICAL'	0.0	0,001
CDG_Y	'ANALYTICAL'	0.0	0,001
CDG_Z	'ANALYTICAL'	2.5 E-01	0.1%
IX_G	'NON_REGRESSION'	1.00956 E+02	0.1%
IY_G	'NON_REGRESSION'	1.00956 E+02	0.1%
IZ_G	'NON_REGRESSION'	1.93836 E+02	0.1%
IXY_G		-8.42942	
IXZ_G		0.0	
IYZ_G		0.0	

12 Summary of the results

The keyword `PRES_REP` (reality or function) and `FORCE_COQUE` (reality or function) can be indifferently used for the elements of hull and of plate, the got results coincide.