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

$E = 200\,000\ MPa$
$\nu = 0.3$
$\rho = 1234.\ kg/m^3$ for modelings I, J and K.

1.2 Geometrical characteristics

One notes:

1) $R_1 = 0.975$ m the interior ray of the cylinder;
2) $R_2 = 1.025$ m the ray external of the cylinder;
3) $R = 1\ m$ the average radius of the cylinder equal to the half the sum of the two preceding rays;
4) $e = 0.05$ m the radial thickness of the cylinder;
5) $h = 0.5$ 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: $P = 10\ MPa$ 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 modelings I, J and K, 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:

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

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

$$\begin{cases} J_{rr} = P \dfrac{a^2}{b^2 - a^2} \left(1 - \dfrac{b^2}{r^2}\right) \\ J_{\theta\theta} = P \dfrac{a^2}{b^2 - a^2} \left(1 + \dfrac{b^2}{r^2}\right) \\ \sigma_{r\theta} = 0 \\ \sigma_{zz} = 2\,\nu\,P \dfrac{a^2}{b^2 - a^2} \end{cases}$$

Passage in the Cartesian system:

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

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: $M = \rho h \pi (R_2^2 - R_1^2) = 2\pi \rho h e R$;

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

1) the tensor of inertia compared to O is worth:

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

1) the tensor of inertia compared to G is worth:

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

For modelings J and K where the trace of a quarter of cylinder of cross-section around an axis OZ on a level perpendicular to this axis is represented

1) the mass per unit height is worth: $M = \rho \frac{\pi}{2} \frac{(R_1 + R_2)}{2} e = \rho \frac{\pi}{2} \mathrm{Re}$;

1) the coordinates of the centre of gravity are: $\begin{pmatrix} x_G \\ y_G \end{pmatrix} = \begin{pmatrix} \frac{2}{\pi} R[1+\frac{1}{12}(\frac{e}{R})^2] \\ \frac{2}{\pi} R[1+\frac{1}{12}(\frac{e}{R})^2] \end{pmatrix}$

1) the tensor of inertia compared to O is worth:

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

1) the tensor of inertia compared to G is worth:

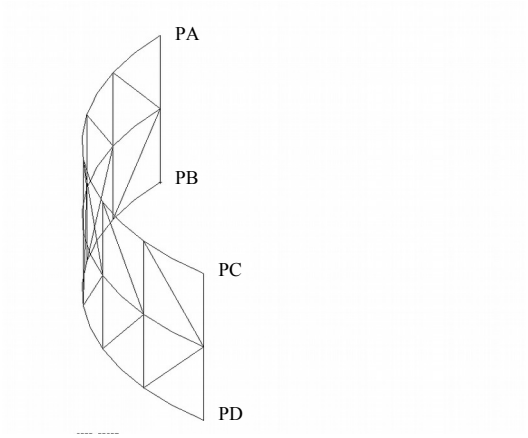
$$\begin{pmatrix} I_{xx} & I_{xy} & I_{xz} \\ I_{xy} & I_{yy} & I_{yz} \\ I_{xz} & I_{yz} & I_{zz} \end{pmatrix} = \begin{pmatrix} \frac{M}{2}R^2[1+\frac{1}{4}(\frac{e}{R})^2] - My_G^2 & \frac{M}{\pi}R^2[1+\frac{1}{4}(\frac{e}{R})^2] - Mx_Gy_G & 0 \\ \frac{M}{\pi}R^2[1+\frac{1}{4}(\frac{e}{R})^2] - Mx_Gy_G & \frac{M}{2}R^2[1+\frac{1}{4}(\frac{e}{R})^2] - Mx_G^2 & 0 \\ 0 & 0 & MR^2[1+\frac{1}{4}(\frac{e}{R})^2] - M(x_G^2+y_G^2) \end{pmatrix}$$

Note:

In practice, one neglects the terms in $(\frac{e}{R})^2$ 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 meshs: 24 COQUE_3D
24 TRIA7

Boundary conditions:

Group of meshs 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 meshs 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 meshs connecting PA and PB
and CD that connecting PC and PD

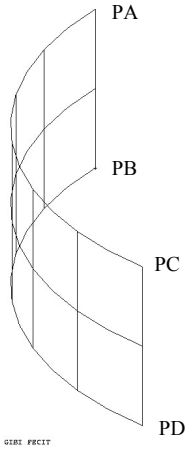
3.2 Sizes tested and results

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 Average layer	'ANALYTICAL'	– 9.81907 10^{-10}	3.3%
	Constraints ($SIXX$)			
	Average layer	'ANALYTICAL'	194.93754	0.7%
	Higher layer	'ANALYTICAL'	200,125	27.%
	Lower layer	'ANALYTICAL'	190,125	27.%
FORCE_COQUE (REALITY)	Displacements Average layer	'ANALYTICAL'	– 9.81907 10^{-10}	3.3%
	Constraints ($SIXX$)			
	Average layer	'ANALYTICAL'	194.93754	0.7%
	Higher layer	'ANALYTICAL'	200,125	27.%
	Lower layer	'ANALYTICAL'	190,125	27.%
FORCE_COQUE (FUNCTION)	Displacements Average layer	'ANALYTICAL'	– 9.81907 10^{-10}	3.3%
	Constraints ($SIXX$)			
	Average layer	'ANALYTICAL'	194.93754	0.7
	Higher layer	'ANALYTICAL'	200,125	27.%
	Lower layer	'ANALYTICAL'	190,125	27.%

4 Modeling B

4.1 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 meshs: 12 COQUE_3D
12 QUAD9

Boundary conditions:

Group of meshs 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 meshs 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

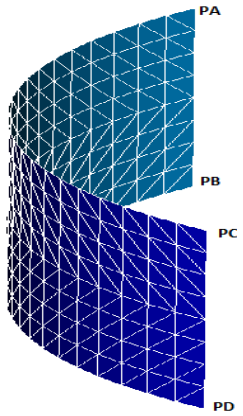
with AB the group of meshs connecting PA and PB
and CD that connecting PC and PD

4.2 Sizes tested and results

Keyword	Identification	Type of Reference	Value of reference	Tolerance
PRES_REP	Displacements Average layer	'ANALYTICAL'	– 9.81907 10^{-10}	1.5%
	Constraints ($SIXX$)			
	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 10^{-10}	1.5%
	Constraints ($SIXX$)			
	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 10^{-10}	1.5%
	Constraints ($SIXX$)			
	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	$Coor_x$	$Coor_y$	$Coor_z$
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 meshs: 192 DKT
192 DST

Boundary conditions:

Group of meshs 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 meshs 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

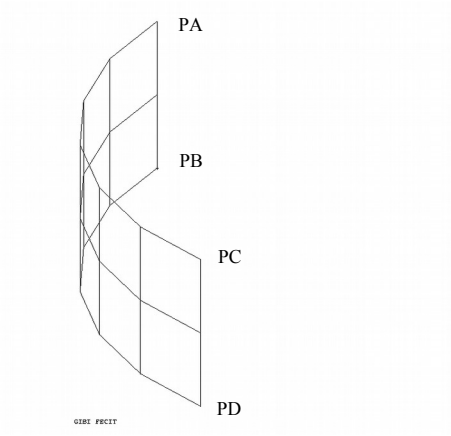
with AB the group of meshs connecting PA and PB
and CD that connecting PC and PD

5.2 Sizes tested and results

Keyword	Identification	Type of Reference	Value of reference	Tolerance
PRES_REP	Displacements Average layer	'ANALYTICAL'	– 9.81907 10 $^{-10}$	2.0%
	Constraints ($SIXX$)			
	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 10 $^{-10}$	2.0%
	Constraints ($SIXX$)			
	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 10 $^{-10}$	2.0%
	Constraints ($SIXX$)			
	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 meshs: 6 DKQ
6 DSQ

Boundary conditions:

Group of meshs 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 meshs 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

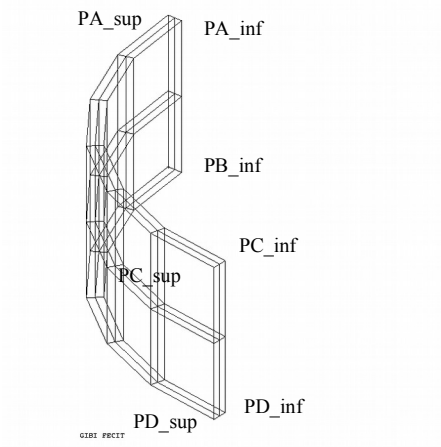
with AB the group of meshs connecting PA and PB
and CD that connecting PC and PD

6.2 Sizes tested and results

Keyword	Identification	Type of Reference	Value of reference	Tolerance
PRES_REP	Displacements Average layer	'ANALYTICAL'	– 9.81907 10 $^{-10}$	1.0%
	Constraints ($SIXX$)			
	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 10 $^{-10}$	1.0%
	Constraints ($SIXX$)			
	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 10 $^{-10}$	1.0%
	Constraints ($SIXX$)			
	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 meshs: 24 meshs HEXA8 3D linear

Boundary conditions:

Group of meshs S_AB :
1) displacement following the axis Y : DY = 0
2) displacement following the axis Z : DZ = 0

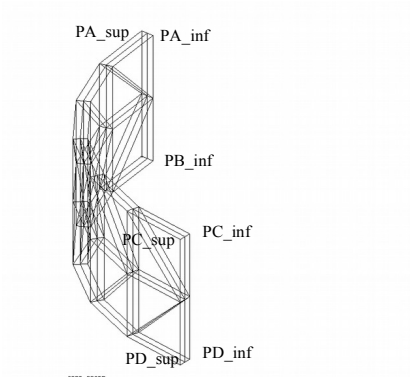
Group of meshs S_CD :
1) displacement following the axis X : DX = 0
2) displacement following the axis Z : DZ = 0

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 meshs: 48 meshs PENTA6 3D linear

Boundary conditions:

Group of meshs S_AB :
1) displacement following the axis Y : DY = 0
2) displacement following the axis Z : DZ = 0

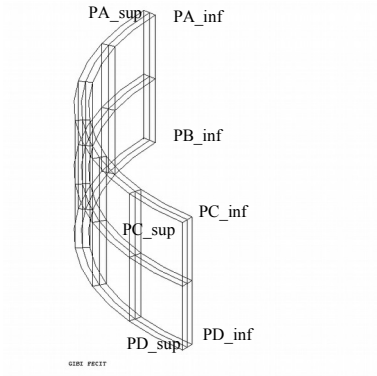
Group of meshs S_CD :
1) displacement following the axis X : DX = 0
2) displacement following the axis Z : DZ = 0

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%
	Lower layer	'ANALYTICAL'	200,125	21%
	Higher layer	'ANALYTICAL'	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	'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 meshs: 24 meshs HEXA20 3D quadratic

Boundary conditions:

Group of meshs S_AB :
1) displacement following the axis Y : DY = 0
2) displacement following the axis Z : DZ = 0

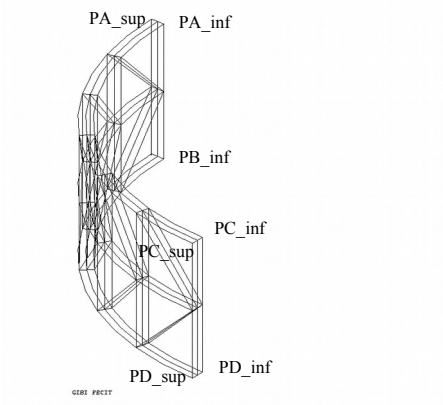
Group of meshs S_CD :
1) displacement following the axis X : DX = 0
2) displacement following the axis Z : DZ = 0

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%
	Lower layer	'ANALYTICAL'	200,125	13%
	Higher layer	'ANALYTICAL'	190,125	11%
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 meshs: 48 meshs PENTA15 3D quadratic

Boundary conditions:

Group of meshs S_AB :
1) displacement following the axis Y : $DY=0$
2) displacement following the axis Z : $DZ=0$

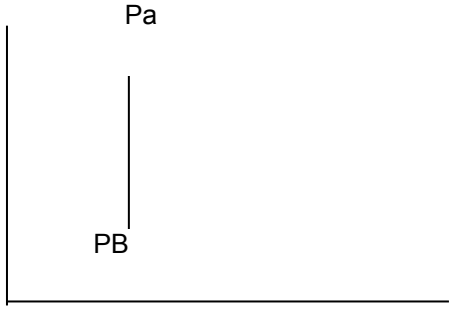
Group of meshs S_CD :
1) displacement following the axis X : $DX=0$
2) displacement following the axis Z : $DZ=0$

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.%
	Lower layer	'NON_DEFINI'	200,125	21.%
	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.%
	Lower layer	'NON_DEFINI'	200,125	21.%
	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 meshs: 2 COQUE_AXI

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

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

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'	$-9.81907\ 10^{-10}$	2%
	Constraints ($SIYY$) Average layer	'NON_DEFINI'	194.93754	10%
FORCE_COQUE (REALITY) with MODI_METRIQUE	Displacements Average layer	'ANALYTICAL'	$-9.81907\ 10^{-10}$	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'	$-9.81907\ 10^{-10}$	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'	$-9.81907\ 10^{-10}$	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 Modeling J

12.1 Characteristics of the grid

Coordinates of the points:

GROUP_NO	$Coor_x$	$Coor_y$
PA	1.0	0.
PC	0.	1.

Characteristics of the elements:

Types of meshs: 10 COQUE_C_PLAN

$R = 1\,m.$
$\rho = 1234.\,kg/m^3$

Boundary conditions:

Group of nodes PA:
1) displacement following the axis $Y = 0$
2) rotation around the axis Z : $DRZ = 0$

Group of nodes PC :
1) displacement following the axis X : $DX = 0$
2) rotation around the axis Z : $DZ = 0$

12.2 Sizes tested and results

Keyword	Identification	Type of Reference	Value of reference	Tolerance
PRES_REP	Displacements Average layer	'ANALYTICAL'	– 9.81907 10 – 10	8%
	Constraints ($SIXX$) Average layer	'NON_DEFINI'	194.93754	3%
FORCE_COQUE (REALITY) with MODI_METRIQUE	Displacements Average layer	'ANALYTICAL'	– 9.81907 10 – 10	8%
	Constraints ($SIXX$)			
	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 10 – 10	8%
	Constraints ($SIXX$)			
	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 10 – 10	8%
	Constraints ($SIXX$)			
	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'	9.69181 E+01	0.1%
CDG_X	'ANALYTICAL'	6.36619 E-01	0.1%
CDG_Y	'ANALYTICAL'	6.36619 E-01	0.1%
CDG_Z	'ANALYTICAL'	0.0	0,001
IX_G	'NON_REGRESSION'	9.17961	0.1%
IY_G	'NON_REGRESSION'	9.17961	0.1%
IZ_G	'NON_REGRESSION'	1.83592 E+01	0.1%
IXY_G		-8.42942	
IXZ_G		0.0	
IYZ_G		0.0	

13 Modeling K

13.1 Characteristics of the grid

Coordinates of the points:

GROUP_NO	$Coor_x$	$Coor_y$
PA	1.0	0.
PC	0.	1.

Characteristics of the elements:

Types of meshs: 10 COQUE_D_PLAN

$R = 1\,m.$
$\rho = 1234.\,kg/m^3$

Boundary conditions:

Group of nodes PA:
1) displacement following the axis $Y = 0$
2) rotation around the axis Z: $DRZ = 0$

Group of nodes PC:
1) displacement following the axis X: $DX = 0$
2) rotation around the axis Z: $DZ = 0$

13.2 Sizes tested and results

Keyword	Identification	Type of Reference	Value of reference	Tolerance
PRES_REP	Displacements Average layer	'ANALYTICAL'	– 9.81907 10^{-10}	8%
	Constraints ($SIXX$) Average layer	'NON_DEFINI'	194.93754	3%
FORCE_COQUE (REALITY) with MODI_METRIQUE	Displacements Average layer	'ANALYTICAL'	– 9.81907 10^{-10}	8%
	Constraints ($SIXX$)			
	Average layer	'ANALYTICAL'	194.93754	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 10^{-10}	8%
	Constraints ($SIXX$)			
	Average layer	'ANALYTICAL'	194.93754	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 10^{-10}	8%
	Constraints ($SIXX$)			
	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'	9.69181 E+01	0.1%
CDG_X	'ANALYTICAL'	6.36619 E-01	0.1%
CDG_Y	'ANALYTICAL'	6.36619 E-01	0.1%
CDG_Z	'ANALYTICAL'	0.0	0,001
IX_G	'NON_REGRESSION'	9.17961	0.1%
IY_G	'NON_REGRESSION'	9.17961	0.1%
IZ_G	'NON_REGRESSION'	1.83592 E+01	0.1%
IXY_G		-8.42942	
IXZ_G		0.0	
IYZ_G		0.0	

14 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.