SSLS10 – Torus under pressure interns uniform

Summary:

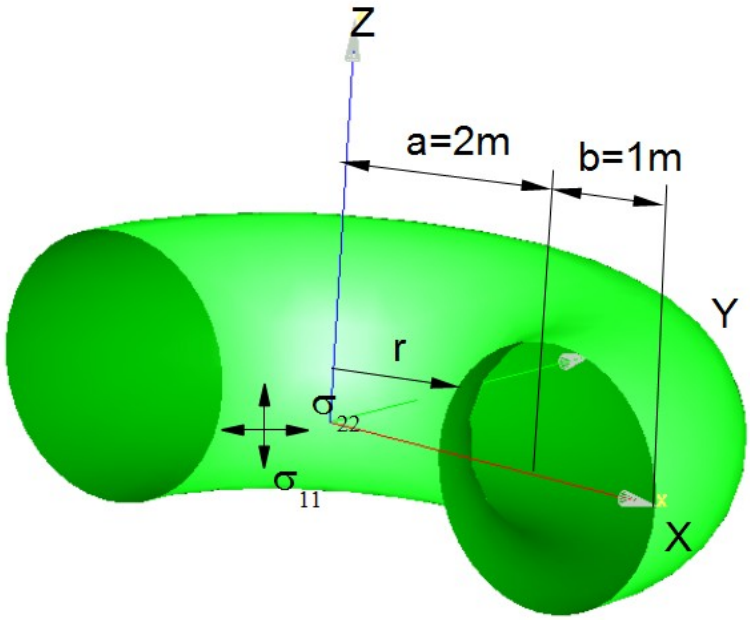
The objective of this test is to validate the calculation of displacements, and of the constraints in subjected torus a pressure has interns uniform.

Modelings :

- Modeling A : DKT with meshs QUAD4/TRIA3
- Modeling B : DST with meshs QUAD4/TRIA3
- Modeling C : Q4G with meshs QUAD4/TRIA3
- Modeling D : COQUE_3D with meshs QUAD9/TRIA7

1 Problem of reference

1.1 Geometry



Thickness: $h=0,02\,m$

1.2 Properties of material

The material is elastic isotropic:

- $E=2,1.\times 10^{11}\,Pa$
- $\nu=0.3$

1.3 Boundary conditions and loadings

Free conditions

Loading:

- Internal pressure: $p=10^{4}\,Pa$

1.4 Initial conditions

Nothing

2 Reference solution

2.1 Method of calculating

The reference solution is a digital solution [1].

If $a-b \leq r < a+b$

- Displacement: $\delta_r = \frac{pb}{2Eh}(r - \nu(r+a))$
- Constraints: $\sigma_{11} = \frac{pb}{2h} \times \frac{r+a}{r}$ $\sigma_{22} = \frac{pb}{2h}$

These formulas are applicable only to the thin tori, such as $\frac{b}{h} > 10$ and of radius of curvature such as $r \times \pi < 100\sqrt{\frac{I_x}{A}}$ with I_x =moment of inertia and A = surface of the geometrical section of the torus

2.2 Sizes and results of reference

- Displacements

Not	$DX(m)$
$r=a-b$	$\delta_r = 1.19 \times 10^{-7}$
$r=a+b$	$\delta_r = 1.79 \times 10^{-6}$

- Constraints

Not	Constraints (Pa)
$\forall r$	$\sigma_{22} = 2{,}5 \times 10^5$
$r=a-b$	$\sigma_{11} = 7.5 \times 10^5$
$r=a+b$	$\sigma_{11} = 4.17 \times 10^5$

2.3 Uncertainties on the solution

Analytical solution

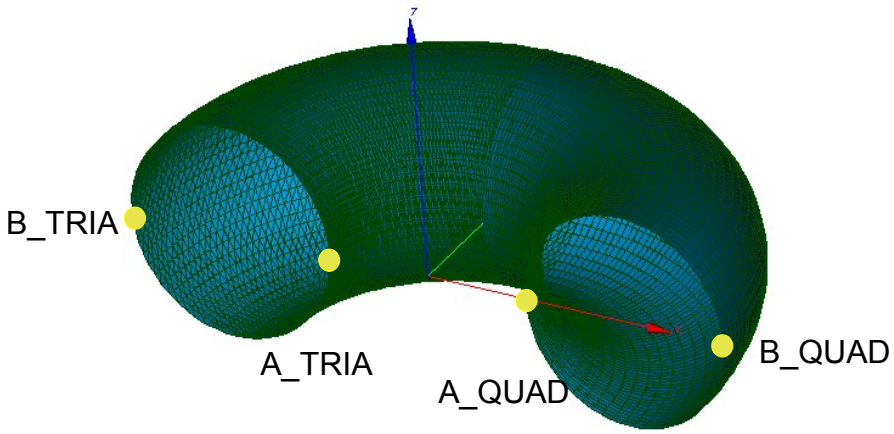
2.4 Bibliographical references

[1] Guide VPCS - Edition 1990.

3 Modeling A

3.1 Characteristics of modeling

A modeling is used DKT .



3.2 Characteristics of the grid

The grid contains 7260 nodes and 10800 meshs of which:

- 7200 meshs of the type TRIA3,
- 3600 meshs of the type QUAD4.

3.3 Sizes tested and results

- Displacements

Identification		Type of reference	Value of reference	Tolerance (%)
Not	Size			
A_QUAD	DX	'ANALYTICAL'	$\delta_r = 1.19\times10^{-7} m$	3.0
A_TRIA		'ANALYTICAL'	$\delta_r = 1.19\times10^{-7} m$	2.0
B_QUAD		'ANALYTICAL'	$\delta_r = 1.79\times10^{-6} m$	1.5
B_TRIA		'ANALYTICAL'	$\delta_r = 1.79\times10^{-6} m$	1.5

- Constraints

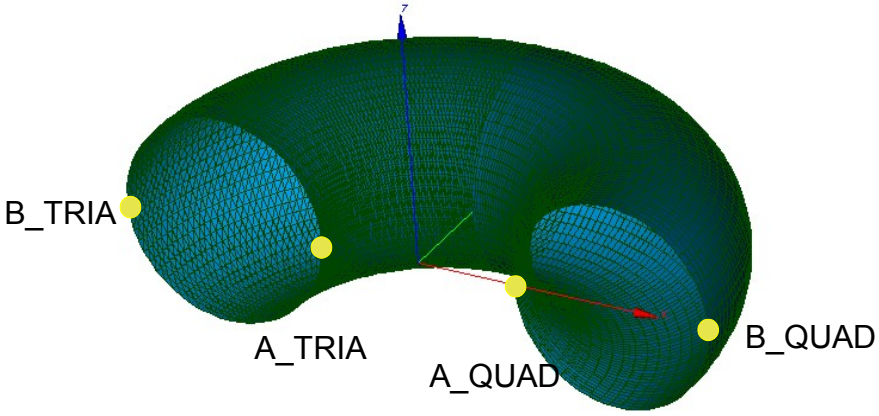
Identification		Type of reference	Value of reference	Tolerance (%)
Not	Size			
A_QUAD	$SIXX$	'ANALYTICAL'	$7.5\times10^{5} Pa$	5.0
A_TRIA		'ANALYTICAL'	$7.5\times10^{5} Pa$	5.0
B_QUAD		'ANALYTICAL'	$4.17\times10^{5} Pa$	3.0
B_TRIA		'ANALYTICAL'	$4.17\times10^{5} Pa$	3.0

Identification		Type of reference	Value of reference	Tolerance (%)
Not	Size			
A _QUAD	*SIYY*	'ANALYTICAL'	$\sigma_{11}=2.5\times10^5\,Pa$	12.0
A _TRIA		'ANALYTICAL'	$\sigma_{11}=2.5\times10^5\,Pa$	12.0
B _QUAD		'ANALYTICAL'	$\sigma_{11}=2.5\times10^5\,Pa$	4.0
B _TRIA		'ANALYTICAL'	$\sigma_{11}=2.5\times10^5\,Pa$	4.0

4 Modeling B

4.1 Characteristics of modeling

A modeling is used DST.



4.2 Characteristics of the grid

The grid contains 7260 nodes and 10800 meshs of which:

- 7200 meshs of the type TRIA3,
- 3600 meshs of the type QUAD4.

4.3 Sizes tested and results

- Displacements

Identification		Type of reference	Value of reference	Tolerance (%)
Not	Size			
A_QUAD	DX	'ANALYTICAL'	$\delta_r = 1.19\times10^{-7} m$	3.0
A_TRIA		'ANALYTICAL'	$\delta_r = 1.19\times10^{-7} m$	2.0
B_QUAD		'ANALYTICAL'	$\delta_r = 1.79\times10^{-6} m$	1.5
B_TRIA		'ANALYTICAL'	$\delta_r = 1.79\times10^{-6} m$	1.5

- Constraints

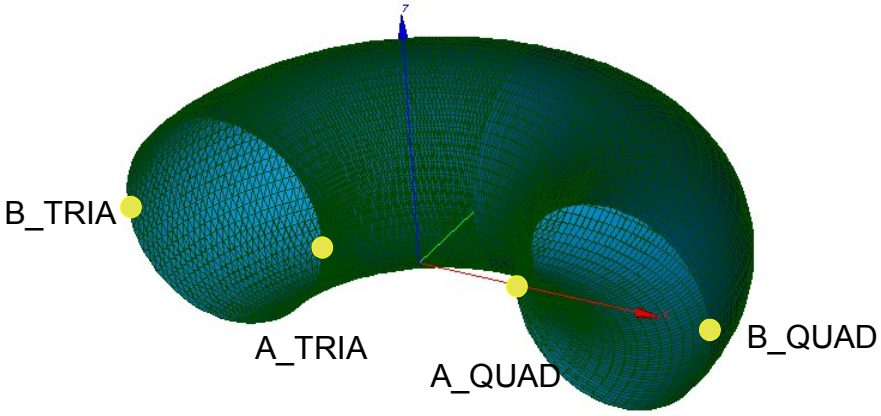
Identification		Type of reference	Value of reference	Tolerance (%)
Not	Size			
A_QUAD	$SIXX$	'ANALYTICAL'	$7.5\times10^{5} Pa$	5.0
A_TRIA		'ANALYTICAL'	$7.5\times10^{5} Pa$	5.0
B_QUAD		'ANALYTICAL'	$4.17\times10^{5} Pa$	3.0
B_TRIA		'ANALYTICAL'	$4.17\times10^{5} Pa$	3.0

Identification		Type of reference	Value of reference	Tolerance (%)
Not	Size			
A _QUAD	*SIYY*	'ANALYTICAL'	$\sigma_{11}=2.5\times10^{5}\,Pa$	12.0
A _TRIA		'ANALYTICAL'	$\sigma_{11}=2.5\times10^{5}\,Pa$	12.0
B _QUAD		'ANALYTICAL'	$\sigma_{11}=2.5\times10^{5}\,Pa$	4.0
B _TRIA		'ANALYTICAL'	$\sigma_{11}=2.5\times10^{5}\,Pa$	4.0

5 Modeling C

5.1 Characteristics of modeling

A modeling is used Q4G.



5.2 Characteristics of the grid

The grid contains 7260 nodes and 10800 meshs of which:

- 7200 meshs of the type TRIA3,
- 3600 meshs of the type QUAD4.

5.3 Sizes tested and results

- Displacements

Identification		Type of reference	Value of reference	Tolerance (%)
Not	Size			
A_QUAD	DX	'ANALYTICAL'	$\delta_r = 1.19\times10^{-7} m$	3.0
A_TRIA		'ANALYTICAL'	$\delta_r = 1.19\times10^{-7} m$	2.0
B_QUAD		'ANALYTICAL'	$\delta_r = 1.79\times10^{-6} m$	1.5
B_TRIA		'ANALYTICAL'	$\delta_r = 1.79\times10^{-6} m$	1.5

- Constraints

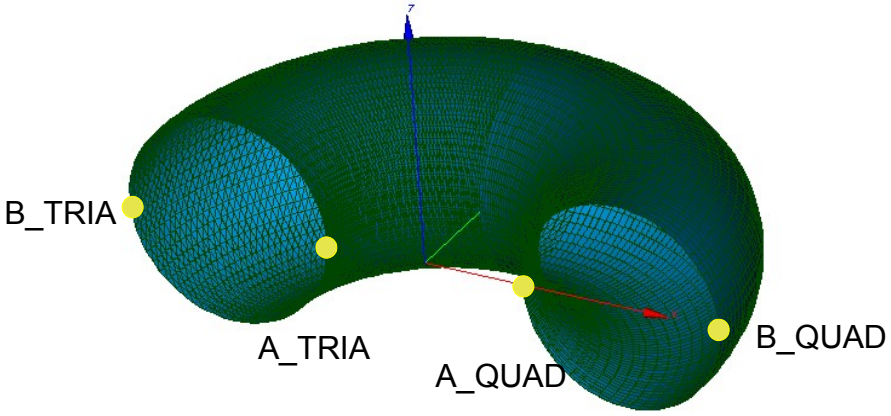
Identification		Type of reference	Value of reference	Tolerance (%)
Not	Size			
A_QUAD	$SIXX$	'ANALYTICAL'	$7.5\times10^{5} Pa$	5.0
A_TRIA		'ANALYTICAL'	$7.5\times10^{5} Pa$	5.0
B_QUAD		'ANALYTICAL'	$4.17\times10^{5} Pa$	3.0
B_TRIA		'ANALYTICAL'	$4.17\times10^{5} Pa$	3.0

Identification		Type of reference	Value of reference	Tolerance (%)
Not	Size			
A_QUAD	SIYY	'ANALYTICAL'	$\sigma_{11}=2.5\times10^5\,Pa$	12.0
A_TRIA		'ANALYTICAL'	$\sigma_{11}=2.5\times10^5\,Pa$	12.0
B_QUAD		'ANALYTICAL'	$\sigma_{11}=2.5\times10^5\,Pa$	4.0
B_TRIA		'ANALYTICAL'	$\sigma_{11}=2.5\times10^5\,Pa$	4.0

6 Modeling D

6.1 Characteristics of modeling

A modeling is used COQUE_3D.



6.2 Characteristics of the grid

The grid contains 7260 nodes and 36120 meshs of which:

- 7200 meshs of the type TRIA7,
- 3600 meshs of the type QUAD9.

6.3 Sizes tested and results

- Displacements

Identification		Type of reference	Value of reference	Tolerance (%)
Not	Size			
A_QUAD	DX	'ANALYTICAL'	$\delta_r = 1.19\times10^{-7} m$	3.0
A_TRIA		'ANALYTICAL'	$\delta_r = 1.19\times10^{-7} m$	2.0
B_QUAD		'ANALYTICAL'	$\delta_r = 1.79\times10^{-6} m$	1.5
B_TRIA		'ANALYTICAL'	$\delta_r = 1.79\times10^{-6} m$	1.5

- Constraints

Identification		Type of reference	Value of reference	Tolerance (%)
Not	Size			
A_QUAD	$SIXX$	'ANALYTICAL'	$7.5\times10^{5} Pa$	0.1
A_TRIA		'ANALYTICAL'	$7.5\times10^{5} Pa$	16.0
B_QUAD		'ANALYTICAL'	$4.17\times10^{5} Pa$	0.1
B_TRIA		'ANALYTICAL'	$4.17\times10^{5} Pa$	3.5

Identification		Type of reference	Value of reference	Tolerance (%)
Not	Size			
A _QUAD	*SIYY*	'ANALYTICAL'	$\sigma_{11}=2.5\times10^5\,Pa$	0.5
A _TRIA		'ANALYTICAL'	$\sigma_{11}=2.5\times10^5\,Pa$	46.0
B _QUAD		'ANALYTICAL'	$\sigma_{11}=2.5\times10^5\,Pa$	0.5
B _TRIA		'ANALYTICAL'	$\sigma_{11}=2.5\times10^5\,Pa$	5.0

7 Summary of the results

Displacements : some is the type of mesh used (TRIA3, QUAD4) , results got for 4 modelings (DKT, DST, Q4G and COQUE_3D) are satisfactory. Compared to the analytical solution, one observes a maximum change of 5%.

Constraints :

- Modelings DKT, DST and Q4G : some is the type of mesh used (TRIA3, QUAD4), the got results are correct. Compared to the analytical solution, one observes a maximum change of 12%. These modelings use elements with facet, by refining the grid one should get better results.
- Modeling COQUE_3D : the mesh of the type QUAD9 give very good performances, the variation observed is of 0.1%. On the other hand the variation is important (46%) for the mesh of the type TRIA7.