

SSNV178 – Cylinder with reinforcement under pressure

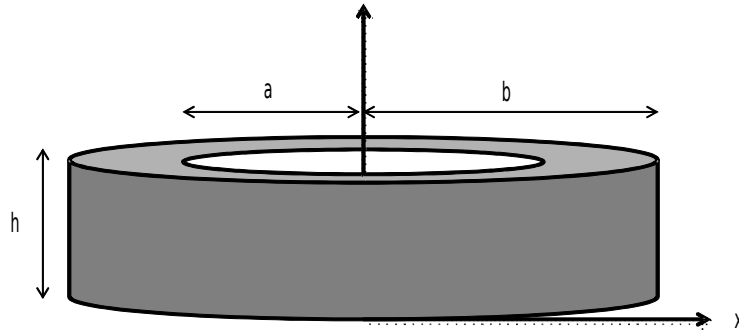
Summary:

One considers a cylinder with reinforcements under pressure. More exactly, a hollow roll 3D, is supplemented on its external face by a circumferential reinforcement. This structure is charged by an internal pressure. Calculation is elastic linear.

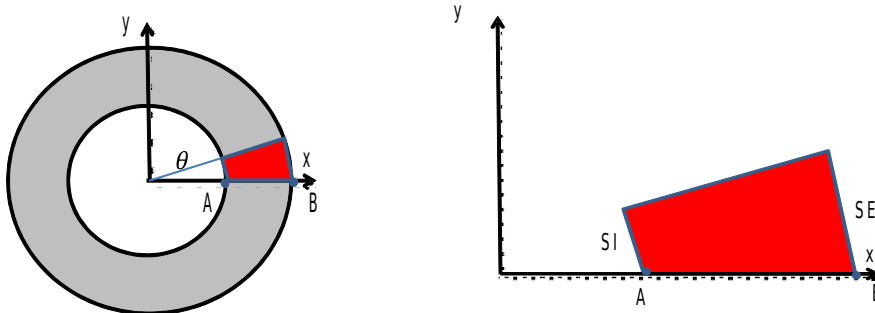
Simulation is compared with an analytical solution in order to validate modelings of reinforcements of the type GRILLE_MEMBRANE on a structure.

1 Problem of reference

1.1 Geometry



The cylinder has an interior ray $a=10\text{ m}$, an external ray $b=20\text{ m}$, a height of $h=0.02\text{ m}$
The circumferential reinforcement, positioned on surface external of the cylinder, has a section per unit of length of 10^{-4} m^2 . The principal direction of the reinforcements is vertical.
Only one portion of the cylinder, corresponding to an angular section $\theta=0.1^\circ$, is modelled.



1.2 Properties of material

The characteristic materials of the concrete forming the hollow roll are:

- $E=20\,000\text{ MPa}$, $\nu=0.2$

Characteristic materials of S reinforcements are:

- $E=200\,000\text{ MPa}$, $\nu=0.0$, $\sigma_y=200\,000\text{ MPa}$, $E_{cr}=20\,000\text{ MPa}$

To model the grids of reinforcements, one uses `RELATION='GRILLE_ISOT_LINE'` in the order `STAT_NON_LINE` . For that the affected behavior with the grids of reinforcements must define the plastic characteristics. In all modelings the behavior of steels must remain in the elastic range, σ_y is given sufficiently large to respect this condition .

1.3 Boundary conditions and loadings

The boundary conditions following are imposed on the modelled angular section:

- a null displacement on the lower surface of the cylinder
- a normal displacement no one on the side faces of the section of the cylinder

The loading consists of an imposed pressure 10^6 Pa on internal surface *SI* section of the cylinder.

1.4 Initial conditions

At the beginning displacements and the constraints are worth zero everywhere.

2 Reference solution

2.1 Method of calculating

The analytical solution of the problem is presented in the documentation of the case test SSNS107 [V6.05.107].

All the behaviors of materials remain in the elastic range.

2.2 Sizes and results of reference

The evaluated sizes are displacements along the axis X points A and B grid (cf Appears). The point A is on the internal surface of the cylinder and the point B on external surface.

Identification	Type of reference	Value of reference
Not formula A Displacement formulates DX	'ANALYTICAL'	8.91925E-04
Not formula B Displacement formulates DX	'ANALYTICAL'	6.21118E-04

The strains and stresses are evaluated in the concrete and the reinforcements on surfaces internal and external of the cylinder. The strains and stresses radial and tangential are respectively $EPXX$, $EPYY$, $SIXX$ and $SIYY$ by neglecting the curve of the elements.

Identification	Type of reference	Value of reference			
		$EPXX$	$EPYY$	$SIXX$	$SIYY$
Concrete IF	'ANALYTICAL'	-6,58E-05	8,92E-05	-1,00E+06	1,58E+06
Concrete SE	'ANALYTICAL'	-7,70E-06	3,11E-05	-3,11E+04	6,15E+05
Steel	'ANALYTICAL'			6,21E+06	

3 Modeling A

3.1 Characteristics of modeling

A voluminal modeling is used 3D for the concrete and a model GRILLE_MEMBRANE for the reinforcements whose meshes supports are quadrangles.

3.2 Characteristics of the grid

The grid contains:

- 100 meshes HEXA20 for the concrete
- 1 mesh QUAD8 for the steel reinforcement

3.3 Remarks

- All the behaviors of materials remain in the elastic range.
- Displacements are evaluated at the points *A* and *B* described previously.
- The strains and stresses are evaluated in the adjacent mesh of the concrete on the internal surface and in the adjacent mesh of the concrete on the external surface.

Field	Size	Place	Reference	Tolerance
DEPL	DX	With	8,92E-04	0,10%
EPSI_ELNO	EPXX	mesh: M100, not: 0	-6,58E-05	0,10%
EPSI_ELNO	EPYY	mesh: M100, not: 0	8,92E-05	0,10%
SIGM_ELNO	SIXX	mesh: M100, not: 0	-1,00E+06	0,10%
SIGM_ELNO	SIYY	mesh: M100, not: 0	1,58E+06	0,10%

Field	Size	Place	Reference	Tolerance
DEPL	DX	B	6,21E-04	0,10%
EPSI_ELNO	EPXX	mesh: M1, not: 0	-7,70E-06	0,10%
EPSI_ELNO	EPYY	mesh: M1, not: 0	3,11E-05	0,10%
SIGM_ELNO	SIXX	mesh: M1, not: 0	-3,11E+04	0,70%
SIGM_ELNO	SIYY	mesh: M1, not: 0	6,15E+05	0,10%
SIGM_ELNO	SIXX	mesh: M502, not: 0	6,21E+06	0,10%

4 Modeling B

4.1 Characteristics of modeling

A voluminal modeling is used 3D for the concrete and a model GRILLE_MEMBRANE for the reinforcements whose meshes supports are triangle.

4.2 Characteristics of the grid

The grid contains:

- 660 meshes TETRA10 for the concrete
- 2 meshes TRIA6 for the steel reinforcement

4.3 Remarks

- All the behaviors of materials remain in the elastic range.
- Displacements are evaluated at the points *A* and *B* described previously.
- The strains and stresses are evaluated on the nodes of the adjacent mesh of the concrete on the internal surface and the adjacent mesh of the concrete on the external surface.

Field	Size	Place	Reference	Tolerance
<i>DEPL</i>	DX	With	8,92E-04	0,10%
EPSI_NOEU	EPXX	With	-6,58E-05	0,10%
EPSI_NOEU	EPYY	With	8,92E-05	0,10%
SIGM_NOEU	SIXX	With	-1,00E+06	0,10%
SIGM_NOEU	SIYY	With	1,58E+06	0,10%

Field	Size	Place	Reference	Tolerance
<i>DEPL</i>	DX	B	6,21E-04	0,10%
EPSI_NOEU	EPXX	B	-7,70E-06	1,00%
EPSI_NOEU	EPYY	B	3,11E-05	0,10%
SIGM_NOEU	SIXX	B	-3,11E+04	5,50%
SIGM_NOEU	SIYY	B	6,15E+05	0,20%
SIGM_ELNO	SIXX	mesh: M1403, not: 0	6,21E+06	0,10%

5 Summary of the results

Various modelings of this case test validate the behavior `GRILLE_MEMBRANE` for a complete structure (cylinder with reinforcement). The results are compared with an analytical solution.