PLEXU04: Cylinder with cables of prestressed under internal pressure in transitory dynamics

Summary:

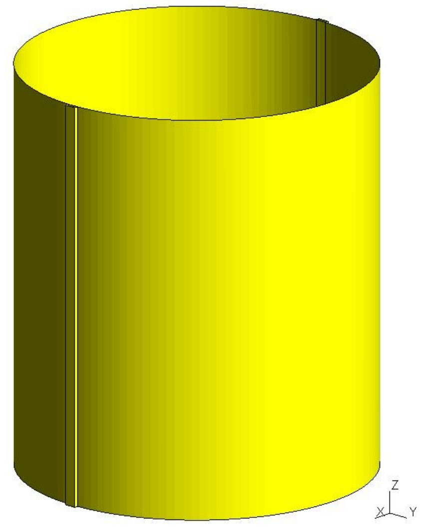
The purpose of this test is of valider all the features installation within the framework of the methodology of Code_Aster/Europlexus chaining for the use of prestressing in Europlexus, on a semi-industrial model (these features having been tested, together and/or separately, only on elementary tests).

For that, one compares the results resulting from the macro-order CALC_EUROPLEXUS with those resulting from the operator DYNA_NON_LINE using the explicit diagram of the differences finished .

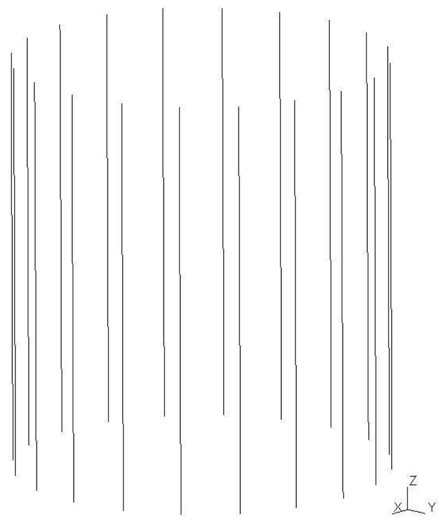
1 Description

1.1 Geometry

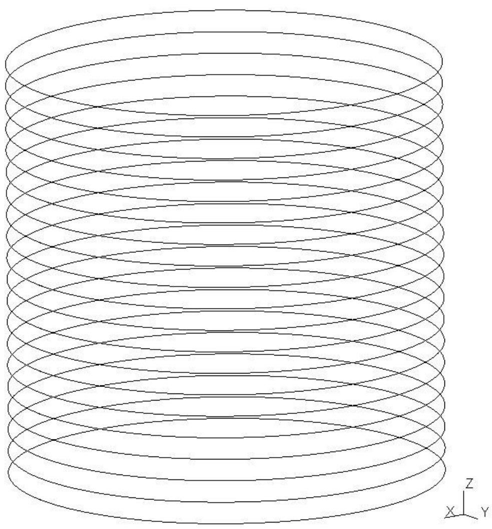
The model of study is a cylindrical envelope of average radius $R=21.9\,m$, height $H=49.6\,m$ and thickness $t=0.6\,m$. Anchorings for the cables on the sides of the cylinder, have as a length $L=1.5\,m$ and for width $l=0.5\,m$. Concerning the cables, they are positioned on the skin external of the cylinder. They are then offset of a distance $e=0.25\,m$. The model is composed of 20 horizontal cables and of 20 vertical cables. The figures below present the various components of the model of study.



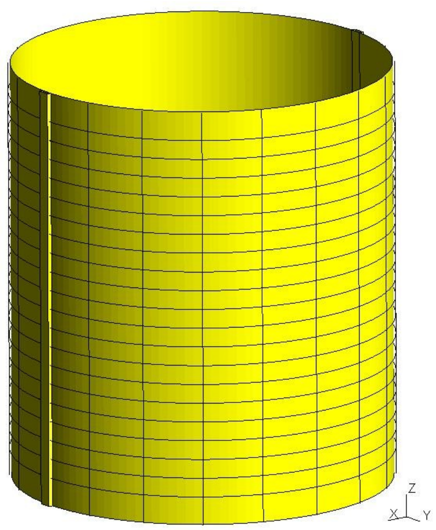
Cylinder



Vertical cables



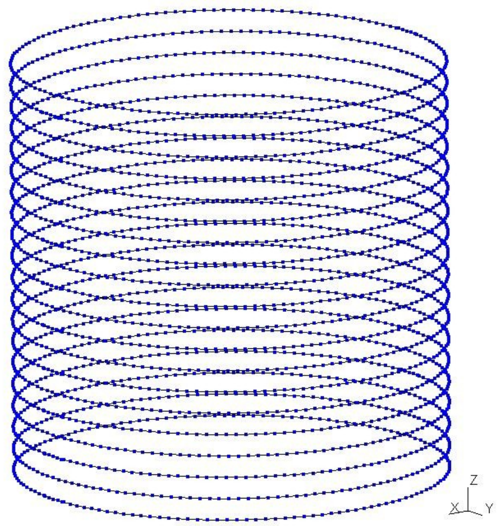
Horizontal cables



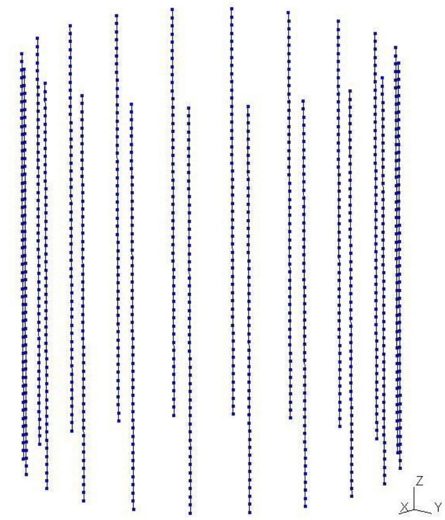
Model of study

1.2 Grid

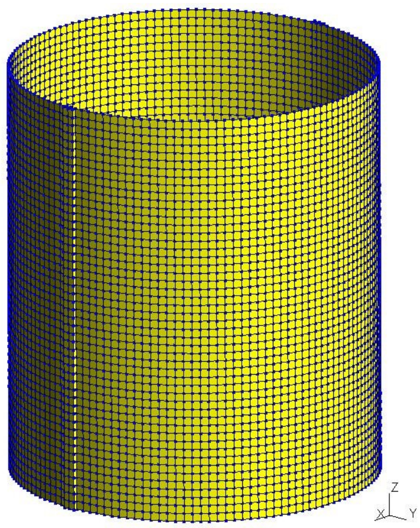
The cables are with a grid with meshs SEG2. The cylinder and anchorings for the cables are with a grid with meshs QUAD4. The discretization spaces some for the various components is to the maximum of $f = 1.0 m$. The following figures represent the grids for the various parts of the model.



Grid of the horizontal cables



Grid of the vertical cables



Grid of the cylinder and anchorings

1.3 Properties of materials

The properties of the concrete for the cylinder and anchorings and of steel for the cables of prestressing are indexed in the following table.

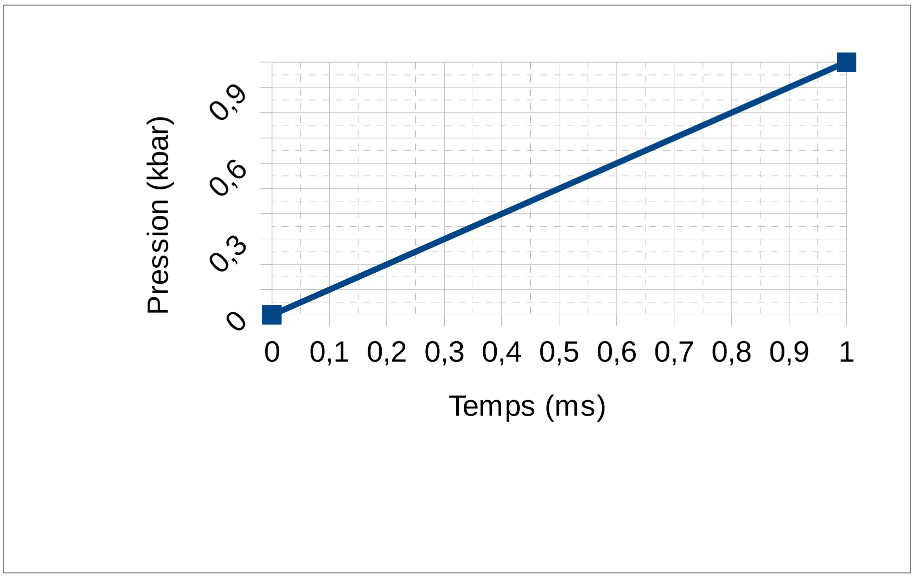
Material	Concrete	Steel
Young modulus	$4\times10^{10}\,Pa$	$1.93\times10^{11}\,Pa$
Poisson's ratio	0.2	0.0
Density	$2500\,kg/m^3$	$7850\,kg/m^3$
Elastic ultimate stress	n/a	$1.94\times10^{11}\,Pa$

1.4 Boundary conditions and loadings

The cylinder and anchorings are embedded in top and bottom.

One initially imposes a tension in the cables equalizes with $3.75\times10^6\,N$. The nodes at the ends of the vertical and horizontal cables are considered “active”.

In the second time, one subjects the cylinder to an internal pressure which increases in the course of time ($P_i=0\,Pa$ with $P_f=1\,kbar$ in $\Delta t=1\,ms$). This loading is represented on the following graph.



1.5 Principal stages of the tests

The macro-order is used DEFI_CABLE_BP to obtain the relations kinematics between the cylinder and the cables as well as the loading related to the tension in the cables.

One launches then the macro-order CALC_PRECONT to carry out the setting into prestressed structure starting from the tensions of the cables given.

The result of this setting in prestressing is given in initial state to the macro-order CALC_EUROPLEXUS in order to calculate the mechanical response of the cylinder prestressed to the internal loading of pressure.

To validate the results resulting from CALC_EUROPLEXUS, one does the same calculation with the operator DYNA_NON_LINE.

From the two concept-results obtained, one extracts:

- the evolution according to the time of displacement on the point of reference located at the middle height of the cylinder, is in $(0, R, H/2)$, noted N_{ref}^{cyl}.
- efforts resulting from membrane Nxx and Nyy, at three moments different in a mesh from the cylinder having a node in common with the node of reference of the cylinder, noted M_{ref}^{cyl}.
- normal effort in an element of the readiest horizontal cable localised of the middle height of the cylinder and more far from anchorings, noted $EL_{ref}^{câb}$.

2 Reference solution

2.1 Results of reference

The results of reference are those obtained with DYNA_NON_LINE.

2.2 Uncertainty on the solution

Inaccuracies of DYNA_NON_LINE.

3 Modeling A

The modeling of hulls proposed is `Q4GG`. The steel wire ropes are modelled by elements `BAR`.

The step of time used for calculations is of $\Delta t=0.1\mu s$, he observes the stability condition (condition CFL).

3.1 Sizes tested and results

The component is tested DY displacement with the node N_{ref}^{cyl} at three different moments.

Node	Component	Moment (ms)	Value of reference (m)	Tolerance (%)
N_{ref}^{cyl}	DY	0	-0.00149171629532	$1.E-6$
N_{ref}^{cyl}	DY	0,5	-0.000144254069992	1.0
N_{ref}^{cyl}	DY	1	0.00927115873819	0.3

One tests the value of two components of the generalized efforts Nxx and Nyy , in the mesh M_{ref}^{cyl} at three different moments.

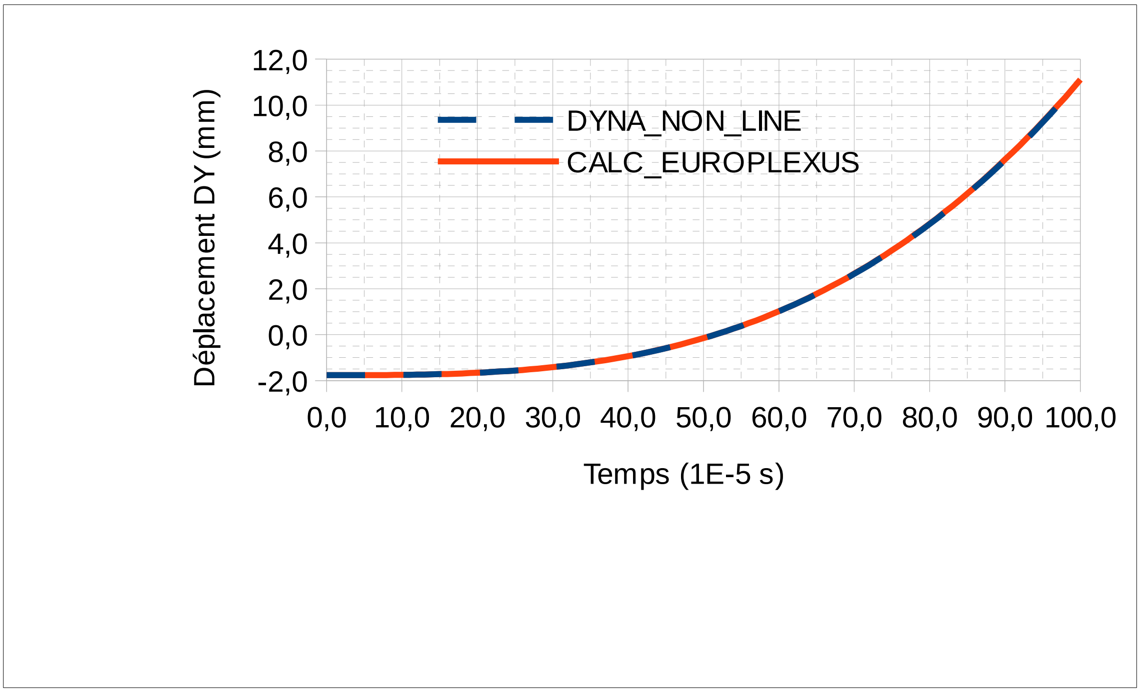
Mesh	Component	Moment (ms)	Value of reference (NR)	Tolerance (%)
M_{ref}^{cyl}	Nxx	0	-298115.503936	$1.0E-6$
M_{ref}^{cyl}	Nxx	0,5	12143.207589	9,0
M_{ref}^{cyl}	Nxx	1	2183571.35963	0.25

Mesh	Component	Moment (ms)	Value of reference (NR)	Tolerance (%)
M_{ref}^{cyl}	Nyy	0	-1671586.18169	$1.0E-6$
M_{ref}^{cyl}	Nyy	0,5	-115744.270149	0.5
M_{ref}^{cyl}	Nyy	1	10770364.4408	0.03

One tests the value ofnormal effort, in the element $EL_{ref}^{câb}$ at three different moments.

Mesh	Component	Moment (ms)	Value of reference (NR)	Tolerance (%)
$EL_{ref}^{câb}$	N	0	3750000.0	$2.0E-3$
$EL_{ref}^{câb}$	N	0,5	3808797.87598	0.2
$EL_{ref}^{câb}$	N	1	4229204.64926	0.5

The graph below trace the evolution of the displacement of the point of reference obtained is with the order DYNA_NON_LINE, that is to say with CALC_EUROPLEXUS.



4 Synthesis

The tests carried out on the most important sizes of the model show that the computed values with CALC_EUROPLEXUS are very close to those obtained with DYNA_NON_LINE.

Within sight of the graph on the evolution of displacement DY point of reference of the cylinder according to time, one notes first of all that prestressing was indeed taken into account, because initial displacement is negative, and thereafter that the two curves are superimposed.

It is concluded that the vertical and horizontal cables as well as the relations kinematics were correctly defined and taken into account during dynamic calculation with the order CALC_EUROPLEXUS, since this order is able correctly to restore the value of displacements, the efforts generalized in the hulls and the efforts in the cables after application of a loading in dynamics.