PLEXU04: Roll with cables of prestressed under internal pressure in transient dynamics

Summarized:

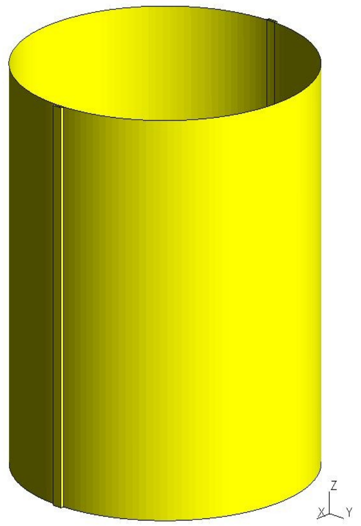
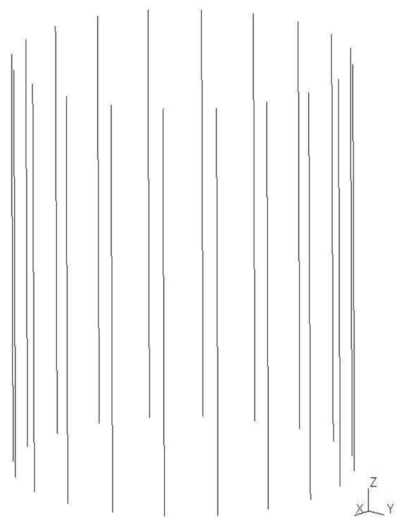
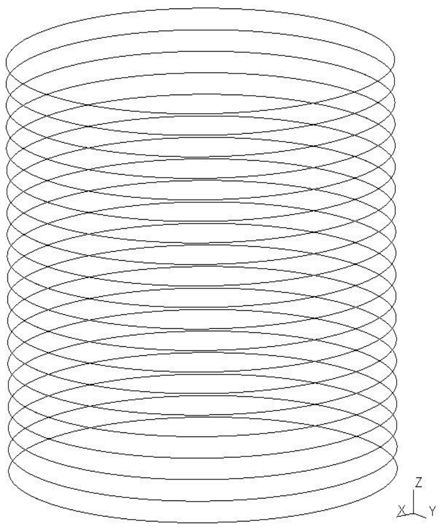
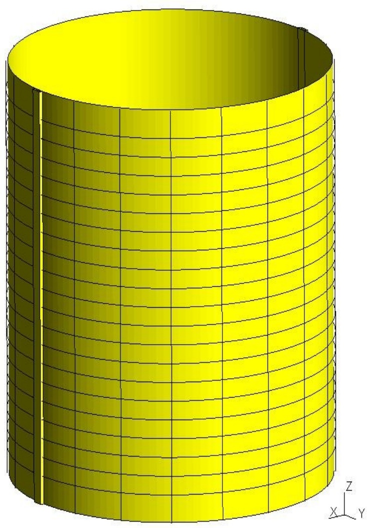
The purpose of this test is validating all the features installation in the frame of the methodology of sequence Code_Aster/Europlexus for the use of prestressing in Europlexus, on a semi-industrial model (these features having been tested, together and/or separately, only on elementary tests).

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

1 Description

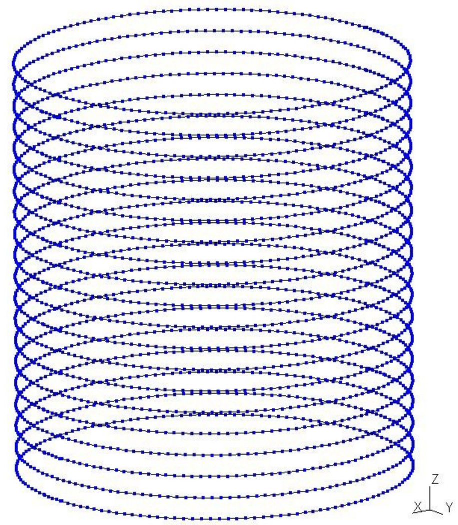
1.1 Geometry

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

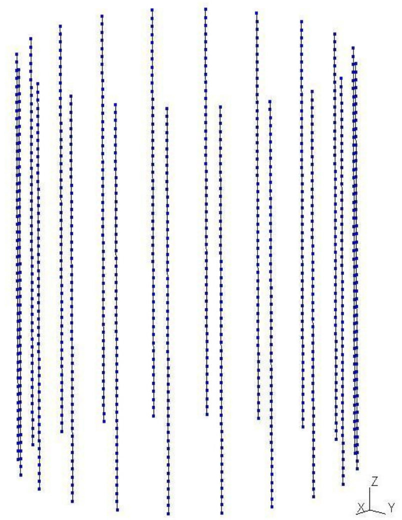
	
Roll	vertical Cables
	
horizontal Cables	Models study

1.2 Mesh

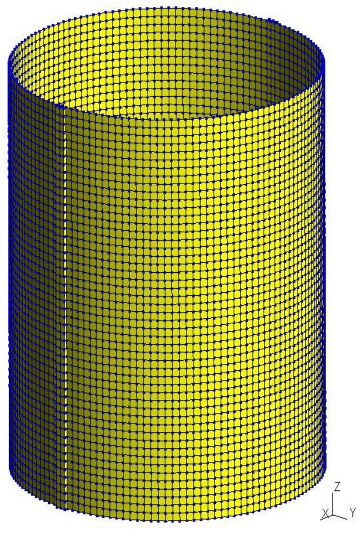
the cables are with a grid with meshes `SEG2`. The cylinder and the anchorages for the cables are with a grid with meshes `QUAD4`. The discretization spaces some for the various components is to the maximum of $f = 1.0 m$. The following figures represent the meshes for the various parts of the model.



Mesh of the horizontal cables



Mesh of the vertical cables



Mesh of the cylinder and the anchorages

1.3 Properties of the materials

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

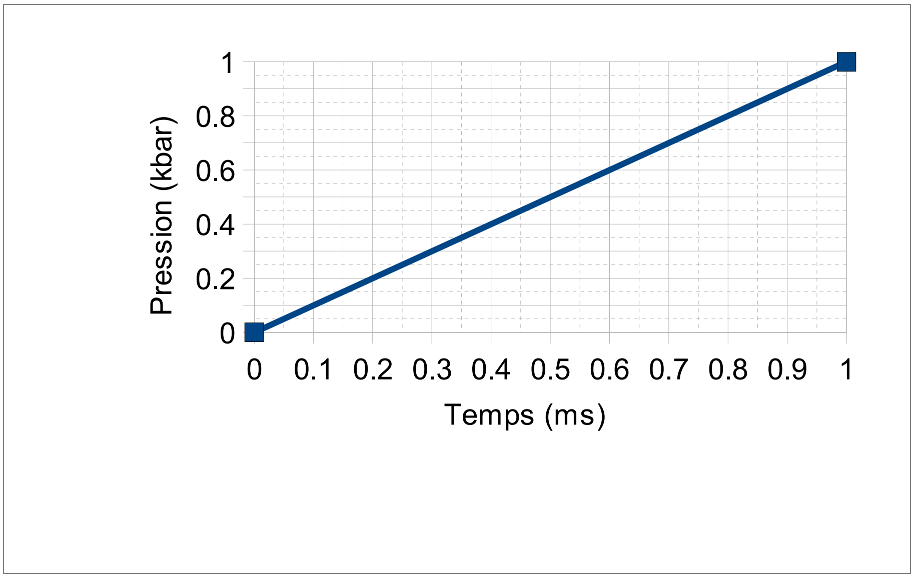
Concrete material		Steel
Modulus Young	$4\times10^{10}\,Pa$	$1.93\times10^{11}\,Pa$
Poisson's ratio	0.2	0.0
Density	$2500\,kg/m^3$	$7850\,kg/m^3$
Stress yield stress	n/a	$1.94\times10^{11}\,Pa$

1.4 Boundary conditions and loadings

the cylinder and the anchorages are embedded in top and bottom.

One initially imposes a tension in the cables equal to $3.75\times10^6\,N$. 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 (of $P_i=0\,Pa$ 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

One uses macro-command DEFI_CABLE_BP to obtain the kinematic relations between the cylinder and the cables as well as the loading related to the tension in the cables.

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

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

To validate the results resulting from CALC_EUROPLEXUS, one does the same calculation with 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, in $(0, R, H/2)$, is noted N_{ref}^{cyl}.
- forces resulting from membrane Nxx and Nyy, at three times 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 force in an element of the readiest horizontal cable localised of the middle height of the cylinder and more far from the anchorages, 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 Modelization With

the modelization of shells proposed is `the Q4GG`. The steel wire ropes are modelled by elements `BARS`.

Time step used for computations is of $\Delta t=0.1\mu s$, it observes the stability condition (CFL condition).

3.1 Quantities tested and results

One tests the component DY displacement with the node N_{ref}^{cyl} at three different times.

Node	Component	Time (ms)	Value of reference (m)	Tolerance (%)
N_{ref}^{cyl}	DY	0	$-1.7604036803488E-03$	$1.E-6$
N_{ref}^{cyl}	DY	0.5	$-1.527861996539E-04$	1.0
N_{ref}^{cyl}	DY	1	0.011074648711162	0.3

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

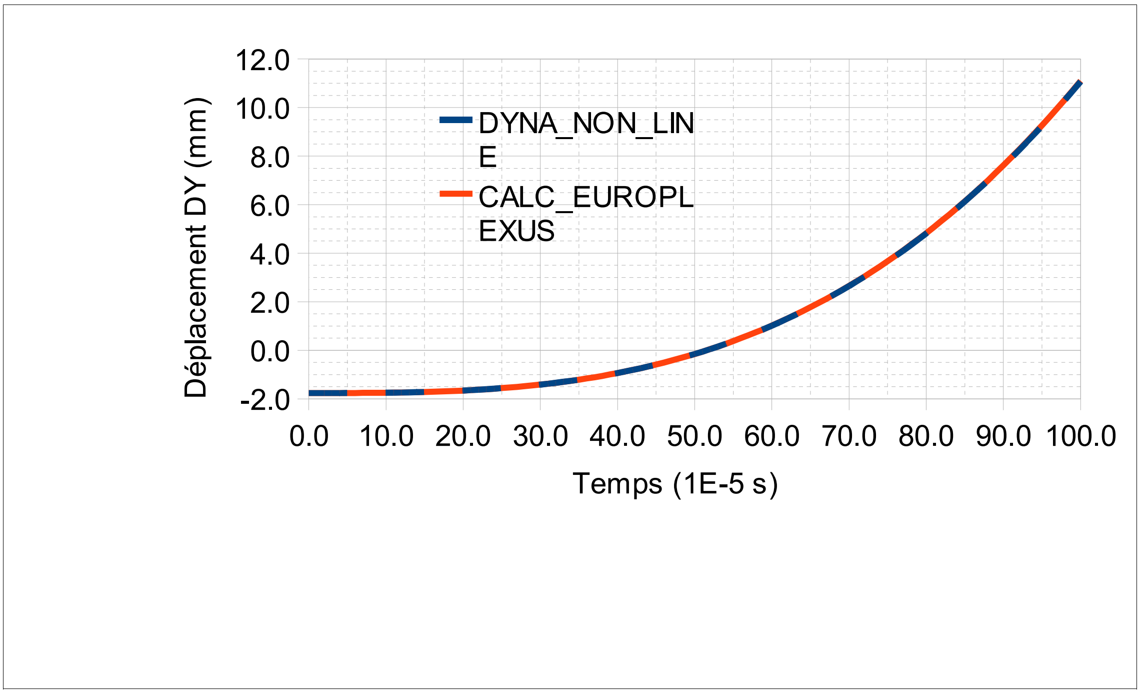
Net	Component	Time (ms)	Value of reference (N)	Tolerance (%)
M_{ref}^{cyl}	Nxx	0	$-2.9835404160758E+05$	$1.0E-6$
M_{ref}^{cyl}	Nxx	0.5	10344.834767446	9,0
M_{ref}^{cyl}	Nxx	1	$2.1694910222616E+06$	0.25

Compon ent	Mesh	Time (ms)	Value of reference (N)	Tolerance (%)
M_{ref}^{cyl}	Nyy	0	$-1.6743997536148E+06$	$1.0E-6$
M_{ref}^{cyl}	Nyy	0.5	$-1.2381395891676E+05$	0.5
M_{ref}^{cyl}	Nyy	1	$1.0726558582381E+07$	0.03

One tests the value of the normal force, in the element $EL_{ref}^{câb}$ at three different times.

Net	Component	Time (ms)	Value of reference (N)	Tolerance (%)
$EL_{ref}^{câb}$	N	0	3.75E+ 06	$2.0E-3$
$EL_{ref}^{câb}$	N	0.5	$3.8177742952981E+06$	0.2
$EL_{ref}^{câb}$	N	1	$4.3036470457482E+06$	0.5

below the graph trace the evolution of the displacement of the reference position obtained either with command DYNA_NON_LINE, or with CALC_EUROPLEXUS.



4 Synthesis

the tests carried out on the most important quantities 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 the displacement DY of the 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 kinematic relations correctly were defined and taken into account during dynamic computation with command CALC_EUROPLEXUS, since this command is able correctly to restore the value of displacements, the forces generalized in the shells and the forces in the cables after application of a loading in dynamics.