PLEXU03 – Validation of the cables of prestressed in CALC_EUROPLEXUS

Summary:

The purpose of this test is to validate the chaining of a calculation of setting in tension of cables of prestressed in Code_Aster with a fast calculation of dynamics in Europlexus via the macro-order of Code_Aster CALC_EUROPLEXUS .

More precisely, it validates the following points in CALC_EUROPLEXUS :

- the use of the elements BAR
- the taking into account of the relations kinematics resulting from DEFI_CABLE_BP
- modeling Q4GG with a group of meshs containing of the triangles and the quadrangles
- the taking into account of an initial state (displacements and constraints)
- the calculation of the constraints starting from the initial trip made by Europlexus
- the use of the keyword BALANCE of ETAT_INIT

Modeling B is also used to validate the calculation of the option FORC_NODA in DEFORMATION = 'PETIT_REAC' for the elements BAR and in DEFORMATION = 'GROT_GDEP' for the elements Q4GG starting from Europlexus.

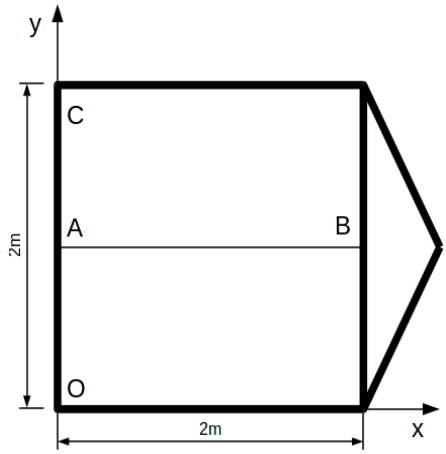
1 Description

1.1 Geometry

The concrete plate is made of a square of $2\,m$ on side and an isosceles triangle of a base of $2\,m$ and a height of $0,5\,m$.

The thickness of the plate is worth $e=0,6\,m$.

A cable, located on the segment $[AB]$, the wife-swapping party crosses of the plate horizontally, with middle height, without eccentricity in the thickness. The surface of the cross-section of the cable is worth $S_a=1,5.10^{-4}m^2$.



1.2 Properties of materials

The plate is out of concrete and the rope steel wire.

Material	Concrete	Steel
Young modulus	$E_b=3.0^{10}\,Pa$	$E_a=2.1.10^{11}\,Pa$
Poisson's ratio	$\nu_b=0.3$	$\nu_a=0.3$
Density	$m_b=2500\,Kg/m^3$	$m_a=7500\,Kg/m^3$

1.3 Boundary conditions

Nœuds O and C are embedded: all the degrees of freedom of translation and rotation are blocked.

2 Modeling A

2.1 Characteristics of modeling

The concrete plate is modelled by two elements Q4GG, first is supported by a quadrangular mesh and the second by a triangular mesh.

The cable is represented by 4 elements BAR, supported by 4 meshs segments with 2 nodes.

2.2 Loadings

The plate is subjected to a pressure which varies according to time:

Moment	0.0	1,00E-005	2,00E-004	5,00E-004	1,00E-003	2,00E-003	3,00E-003
Pressure in Pa	0.0	2,00E+003	1,00E+005	1,00E+006	2,50E+006	7,00E+006	0.0

One imposes initially no tension in the cable.

2.3 Stages of the test

After the definition of the model, materials and loadings, one uses the macro-order DEFI_CABLE_BP to obtain the relations kinematics between the plate and the cable.

One launches then the orders CALC_EUROPLEXUS and DYNA_NON_LINE with the same models, materials, loadings,… etc displacements resulting from the results of these two orders are compared to validate the good taking into account of the relations kinematics between plate and cable in Europlexus.

The order IMPR_RESU is called to make sure that the recovery of the results resulting from Europlexus is well carried out.

2.4 Values tested

One compares the displacements obtained with CALC_EUROPLEXUS with those obtained with DYNA_NON_LINE on Nœud in the middle of the cable, the latter being used as reference.

Node	Moment	Component	Value of reference
NB001003	4,00E-004	DZ	2.8117346211E-05

3 Modeling B

3.1 Characteristics of modeling

Identical with modeling A

3.2 Loadings

One imposes an initial tension in the cable of a value of $2,0\text{E}5\,N$.

3.3 Stages of the test

After the definition of the model, materials and loadings, one uses the macro-order DEFI_CABLE_BP to obtain the relations kinematics between the plate and the cable and to determine the initial tension in each element of cable. The keyword RELIEVING is not informed, all the elements of cables thus have a tension of $2,0\text{E}5\,N$.

The macro-order is used CALC_PRECONT to carry out the setting in tension of the concrete starting from the concept cable_precont resulting from DEFI_CABLE_BP.

The result resulting from macro-order CALC_PRECONT is then given like initial state to CALC_EUROPLEXUS. Displacements and constraints (CONSTRAINT = ' OUI') are transmitted to Europlexus. No additional expenditure is given, the goal being to check the balance of the system. This is why one does not force balance in Europlexus (BALANCE = 'NOT').

After several steps of time, one checks that displacements and the constraints did not evolve.

3.4 Values tested

Results resulting from CALC_PRECONT :

Node	Field	Inst.	Comp.	Value of ref.	Reference	Tolerance
NB002002	FORC_NODA	1,0	DY	1.30712E−01	SOURCE_EXTERNE	1,0E-5
NC001004	FORC_NODA	1,0	DY	−2.00000E+05	SOURCE_EXTERNE	1,0E-5

Results resulting from CALC_EUROPLEXUS : (Analytical References)

Node	Moment	Component	Value of reference	Tolerance
NB001002	1,0	DX	−0.000106115467427	1,0E-6
NC001004	1,0	DX	−7.95866005703E−05	1.0E−4

Mesh	Not	Moment	Component	Value of reference	Tolerance
SG001001	1	1,0	N	2.0E+05	1,0E-6
TR001001	1	1,0	NYY	30081.6876841	1,0E-6
QD001001	4	1,0	NYY	−24501.4600173	3.0E−5

4 Modeling C

4.1 Characteristics of modeling

Identical with modeling A

4.2 Loadings

The plate is subjected to a static loading of pressure which varies linearly according to time.

Moment	0.0	1.0
Pa pressure	0.0	10.0

One imposes initially no tension in the cable.

4.3 Stages of the test

After the definition of the model, materials and loadings, one uses the macro-order DEFI_CABLE_BP to obtain the relations kinematics between the plate and the cable.

One does a static calculation with the loading of pressure using the operator STAT_NON_LINE in order to build an initial state.

The result resulting from the operator STAT_NON_LINE is then given like initial state to CALC_EUROPLEXUS. Only displacements are transmitted to Europlexus (CONSTRAINT = ' NON'). No additional expenditure is given, the goal being to check that the constraints calculated by Europlexus are the same ones as those calculated by Code_Aster.

Note: To find the same constraints static calculation in Code_Aster must imperatively be made in great displacements because it is the kinematics used by Europlexus. Moreover it is necessary to give to the operand NITER the number of steps of time that carried out in Code_Aster to arrive in its final state during static calculation.

CALC_EUROPLEXUS 3 times are called:

- CONSTRAINT = ' NON' and BALANCE = ' OUI' :

One checks at the initial moment and the final moment that the found constraints are equal to those calculated by Code_Aster. As balance was forced there should not be differences between the initial state and the final state.

- CONSTRAINT = ' NON' and BALANCE = ' OUI' :

This time one does not give the load of static calculation to CALC_EUROPLEXUS. That should not modify the results compared to the preceding case. The only difference is that the fictitious external forces added by Europlexus to be with balance will be more important. One checks at the initial moment and the final moment that the found constraints are equal to those calculated by Code_Aster.

- CONSTRAINT = ' NON' and BALANCE = ' NON' :

One checks at the initial moment that the found constraints are equal to those calculated by Code_Aster. Balance not being forced, one can note light evolutions of displacement and of the constraints between the initial state and the final state.

4.4 Values tested

Results resulting from STAT_NON_LINE :

Mesh	Not	Moment	Component	Value of reference	Tolerance
QD001001	4	1,00E+000	QX	1.24999999663E+01	1E-6
TR001001	1	1,00E+000	MXX	−0.416666620634	1E-6
SG001001	1	1,00E+000	N	8.32299514012E−05	1E-6

Results resulting from calculation CALC_EUROPLEXUS n°1 and n°2:

Initial moment and final moment:

Mesh	Not	Component	Value of reference	Tolerance
QD001001	4	QX	1.24999999663E+01	1E-6
TR001001	1	MXX	−0.416666620634	2E-6
SG001001	1	N	8.32299513977E−05	1E-6

Results resulting from calculation CALC_EUROPLEXUS n°3:

Initial moment:

Mesh	Not	Component	Value of reference	Tolerance
QD001001	4	QX	1.24999999663E+01	1E-6
TR001001	1	MXX	−0.416666620634	2E-6
SG001001	1	N	8.32299513977E−05	1E-6

Final moment:

Mesh	Not	Component	Value of reference	Tolerance	CRITERION
QD001001	4	QX	12.5000127517	5E-6	'RELATIVE'
TR001001	1	MXX	−0.416668864726	5E-5	'RELATIVE'
SG001001	1	N	7.58009308692E−05	1E-5	'ABSOLUTE'

5 Synthesis

Calculation done with Europlexus via CALC_EUROPLEXUS took into account the elements well BAR.

The test on displacement shows that the relations kinematics were correctly taken into account. The treatment of the elements quadrangles and triangles in the same group of meshs was well made.

One could also note that the taking into account of an initial state is made correctly, as well as the calculation of the constraints starting from displacements by Europlexus.