SSNS112 – Test of compression and alternate tensile of a reinforced concrete post

Summary:

The objective of this test is to validate the alternate uniaxial answer of a reinforced concrete beam, on the basis of experimental test, modelled by the laws:

- `GLRC_DM` , [R7.01.32] , L reinforced concrete oi generalized used with elements `DKTG` ;
- `MAZARS_GC` , [R5.03.09] , L concrete 1D oi, associated with a non-linear law for steel `VMIS_CINE_GC` on a multifibre model of beam `POU_D_EM` ;
- `DHRC` , [R7.01.37] , lo reinforced concrete l homogenized used with elements `DKTG` .

1 Problem of reference

1.1 Geometry

One considers a reinforced concrete post length $0{,}7\,m$, according to the axis Ox , of square section of height and width equalizes with $0{,}15\,m$.

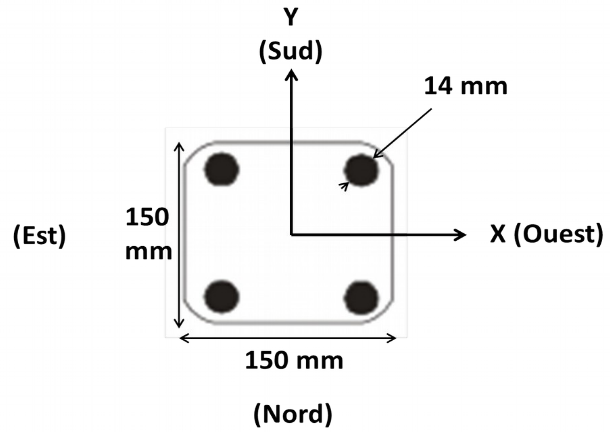

Figure 1: section of the post out of reinforced concrete.

The longitudinal reinforcements are four $HA14$.
The transverse reinforcements are not taken into account in modelings hereafter.
For modeling A, one uses two beds of reinforcements X and Y of $2{,}053\ 10^{-3} m^2/m$.
For modeling B, one uses only one steel fibre of section $6{,}15\,mm^2$.

1.2 Properties of material

The law of behavior of GLRC_DM has the following parameters for the concrete:

- Young modulus: $E=28\,500\,MPa$
- Poisson's ratio: $\nu=0.2$
- Maximum constraint in compression: $\sigma_c=25\,MPa$
- Deformation with the peak in compression: $\epsilon_c=2{,}25.\ 10^{-3}$
- Maximum constraint in traction: $\sigma_t=2{,}94\,MPa$

The parameters for steel are:

- Young modulus: $E=195\,000\,MPa$
- Poisson's ratio: $\nu=0.3$
- Elastic limit: $\sigma_y=610\,MPa$
- Tangent module (plastic slope): $E_t=19{,}5\,MPa$

The operator is used DEFI_GLRC for obtaining the parameters of the law GLRC_DM. The concrete stress was reduced to $\sigma_t=1{,}6\,MPa$. Moreover, the parameters are also fixed $\gamma_c=0{,}35$ and $\alpha_c=60$ for non-linear behaviour in compression.

The elastic module are equivalent out of membrane, cf [R7.01.32], is worth with these data materials: $E_{eq}^{m}=34021.0\,MPa$, that is to say a membrane stiffness according to the direction Ox : $E_{eq}^{m}*S=765.393\,MN$.

The operator DEFI_MATER_GC was used to determine the parameters of the laws MAZARS_GC and VMIS_CINE_GC.

1.3 Boundary conditions and loadings

An end of the beam, edge A , is blocked and one imposes at the other end, edge B , an effort distributed of resultant $FX=1\,kN$ according to the direction X .

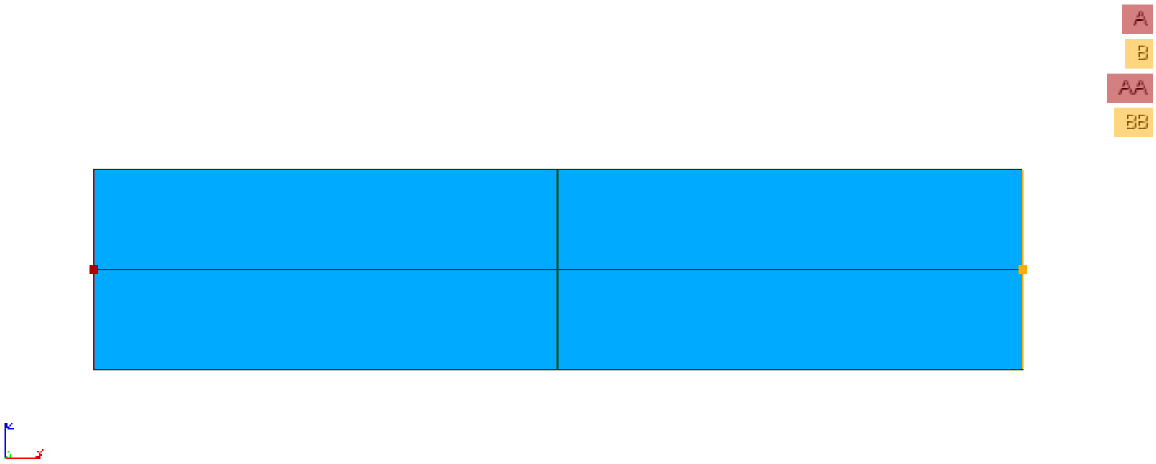

Figure 2: section of the reinforced concrete post.

The cycles of loading are defined by:

t	Multiplying coefficient on the force FX
0,0	0,0
1,0	-250
3,0	55
5,0	-365
7,0	176
9,0	-490
11,0	298
13,0	-675
15,0	368
17,0	-790
19,0	376

1.4 Initial conditions

Nothing.

2 Reference solution

The reference solution is given by experimental results, acquired on the test named test QJ5TC, provided in [1]. On the basis of cycle forces – deformation measured on average on the post, one identifies, cf Figure 1:

- a range of deformations ranging between -0.002 and 0.003, i.e. not causing general plastic deformations of steels within sight of the characteristics of steel, except potentially locally on the way of the cracks,
- an elastic equivalent axial stiffness of $743{,}7 MN$,
- an equivalent axial stiffness post-damage in traction of $120{,}1 MN$, that is to say a relationship between the two of $0{,}161$.

2.1 Bibliographical references

[1] BENMANSOUR M.B. Modeling of the alternate cyclic behavior of the reinforced concrete. Application to various static tests of posts.
Doctorate of the National school of the Bridges and Fitted. January 6th, 1997.

3 Modeling A

3.1 Characteristics of modeling

A modeling is used DKTG. The law of behavior is GLRC_DM.

3.2 Characteristics of the grid

The grid contains 4 elements of the type QUAD4.

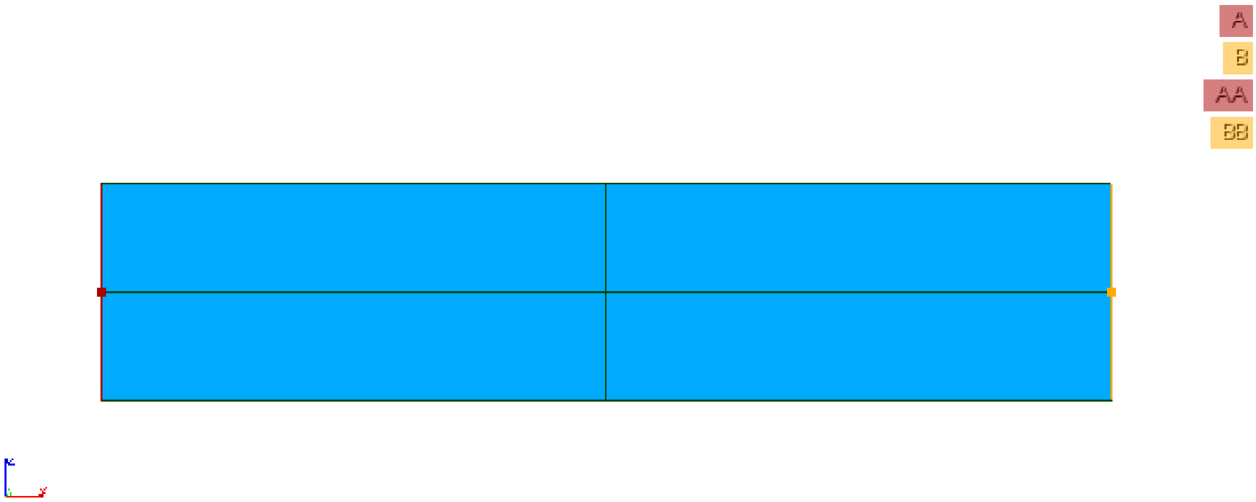

Figure 3 : Grid modeling A.

3.3 Sizes tested and results

Displacement is tested DX node BB located at the center of the edge B .

Identification	Type of reference	Value of reference	Tolerance
Moment 1.0	'SOURCE_EXTERNE'	-2.436805E-4	4%
Moment 3.0	'SOURCE_EXTERNE'	1.689212E-3	40%
Moment 5.0	'SOURCE_EXTERNE'	-3.891909E-4	1%
Moment 7.0	'SOURCE_EXTERNE'	9.398004E-4	20%
Moment 9.0	'SOURCE_EXTERNE'	-5.599223E-4	25%
Moment 11.0	'SOURCE_EXTERNE'	1.5470623E-3	3%
Moment 13.0	'SOURCE_EXTERNE'	-1.1283811E-3	5%
Moment 15.0	'SOURCE_EXTERNE'	1.9670126E-3	1%
Moment 17.0	'SOURCE_EXTERNE'	-1.3747783E-3	8%
Moment 19.0	'SOURCE_EXTERNE'	1.9887658E-3	2.5%

The axial answer of the beam and the experimental results are presented Figure 4.

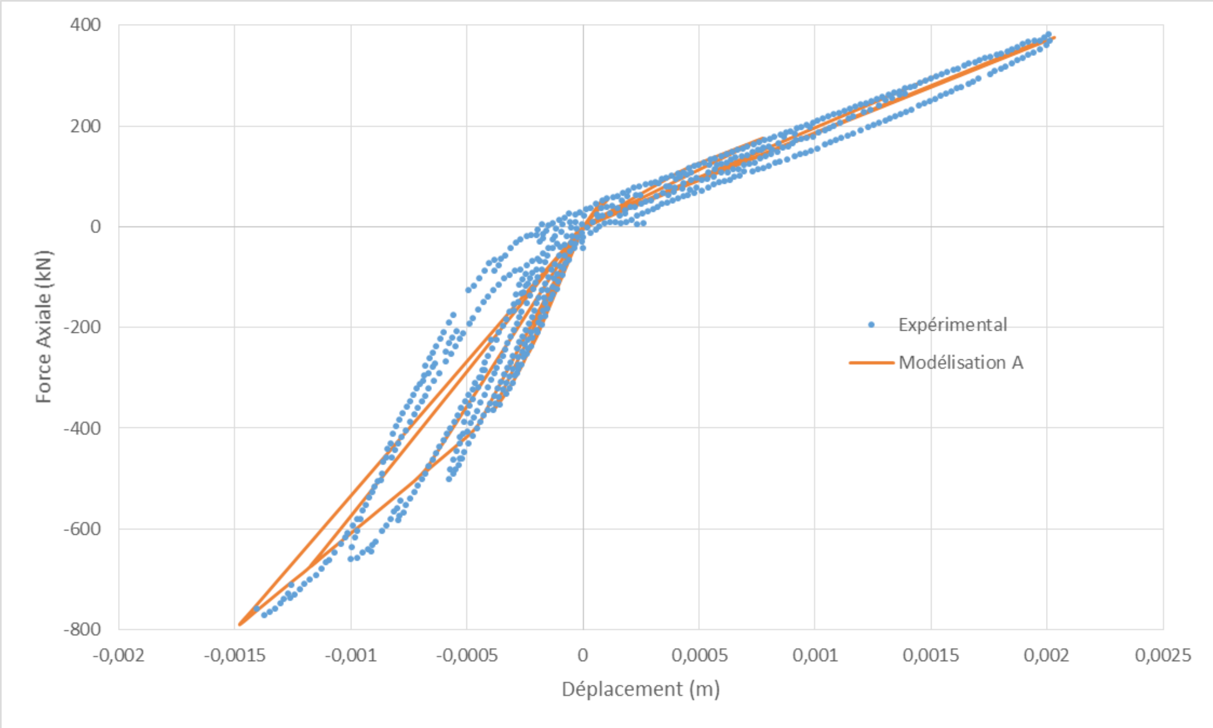

Figure 4 : answer of modeling A

4 Modeling B

4.1 Characteristics of modeling

A modeling is used POU_D_EM. The law of behavior of the fibres concrete is MAZARS_GC. The law of behavior of the fibres steel is VMIS_CINE_GC.

4.2 Characteristics of the grid

The grid contains an element of the type SEG2. The section of the beam is made up of a concrete fibre and a steel fibre.

4.3 Sizes tested and results

The displacement of the node is tested B .

Identification	Type of reference	Value of reference	Tolerance
Moment 1.0	'SOURCE_EXTERNE'	-2.436805E-4	5%
Moment 3.0	'SOURCE_EXTERNE'	1.689212E-3	30%
Moment 5.0	'SOURCE_EXTERNE'	-3.891909E-4	5%
Moment 7.0	'SOURCE_EXTERNE'	9.398004E-4	2%
Moment 9.0	'SOURCE_EXTERNE'	-5.599223E-4	9%
Moment 11.0	'SOURCE_EXTERNE'	1.5470623E-3	6%
Moment 13.0	'SOURCE_EXTERNE'	-1.1283811E-3	10%
Moment 15.0	'SOURCE_EXTERNE'	1.9670126E-3	4%
Moment 17.0	'SOURCE_EXTERNE'	-1.3747783E-3	5%
Moment 19.0	'SOURCE_EXTERNE'	1.9887658E-3	6%

The axial answer of the beam and the experimental results are presented Figure 5.

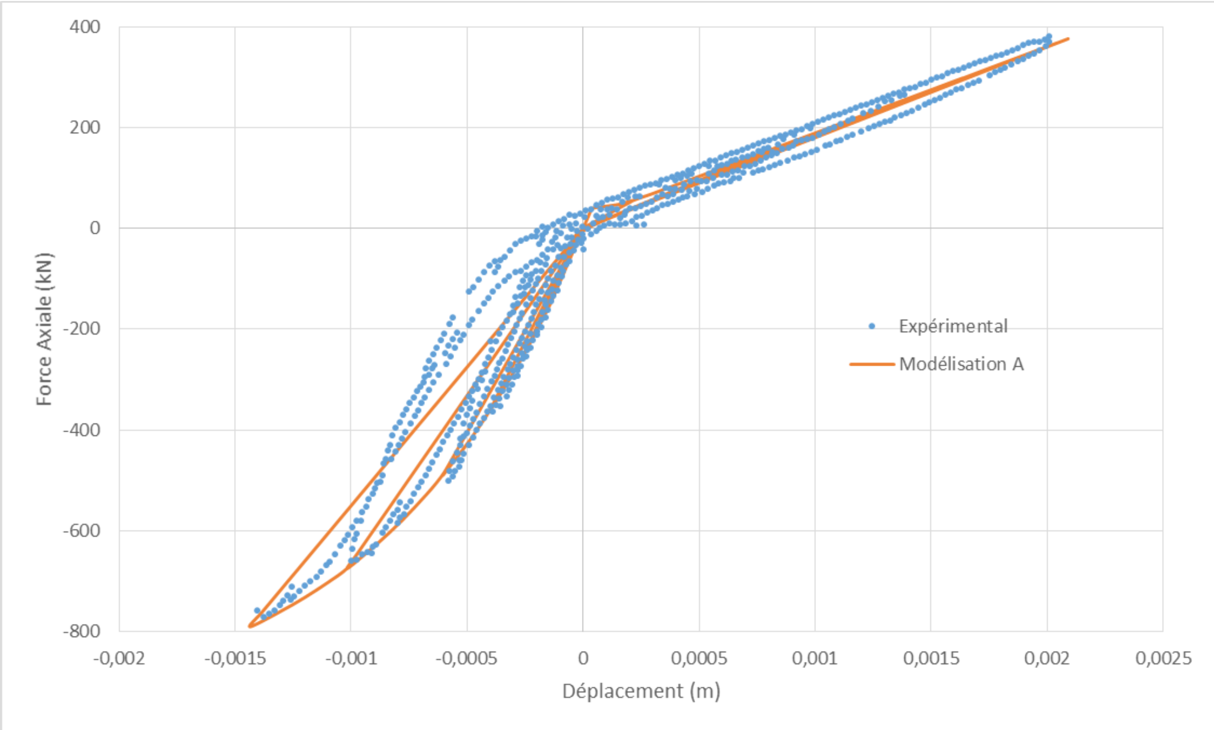

Figure 5 : answer of modeling B

5 Modeling C

5.1 Characteristics of modeling

A modeling is used DKTG. The law of behavior is DHRC.

5.2 Characteristics of the grid

The grid contains 4 elements of the type QUAD4.

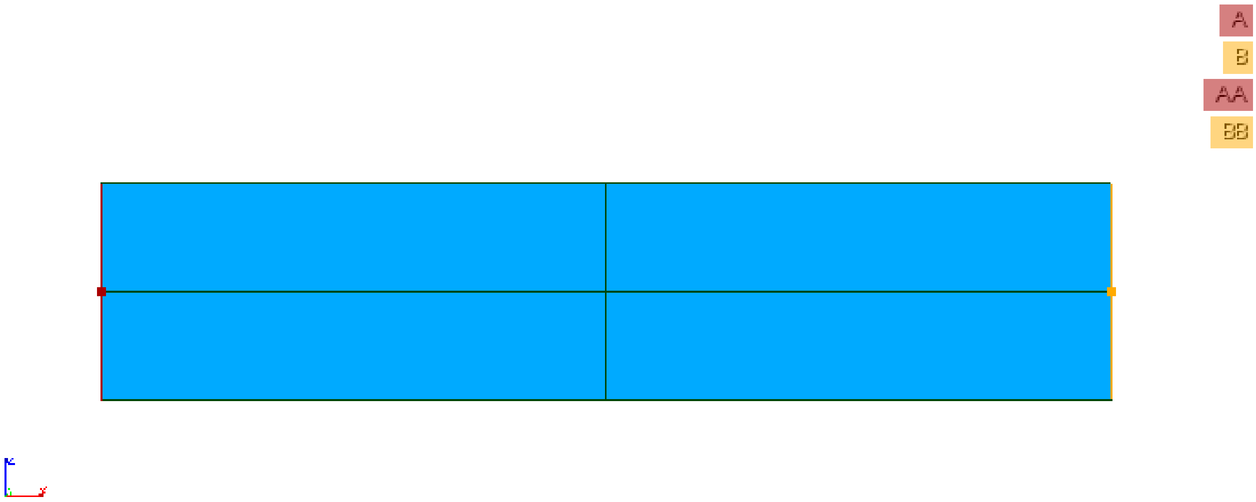

Figure 6 : Grid modeling C.

5.3 Sizes tested and results

Displacement is tested DX node BB located at the center of the edge B.

Identification	Type of reference	Value of reference	Tolerance
Moment 1.0	'SOURCE_EXTERNE'	-2.436805E-4	4%
Moment 3.0	'SOURCE_EXTERNE'	1.689212E-3	70%
Moment 5.0	'SOURCE_EXTERNE'	-3.891909E-4	12%
Moment 7.0	'SOURCE_EXTERNE'	9.398004E-4	25%
Moment 9.0	'SOURCE_EXTERNE'	-5.599223E-4	25%
Moment 11.0	'SOURCE_EXTERNE'	1.5470623E-3	7%
Moment 13.0	'SOURCE_EXTERNE'	-1.1283811E-3	2%
Moment 15.0	'SOURCE_EXTERNE'	1.9670126E-3	2%
Moment 17.0	'SOURCE_EXTERNE'	-1.3747783E-3	0.1%
Moment 19.0	'SOURCE_EXTERNE'	1.9887658E-3	3%

The axial answer of the beam and the experimental results are presented Figure 7.

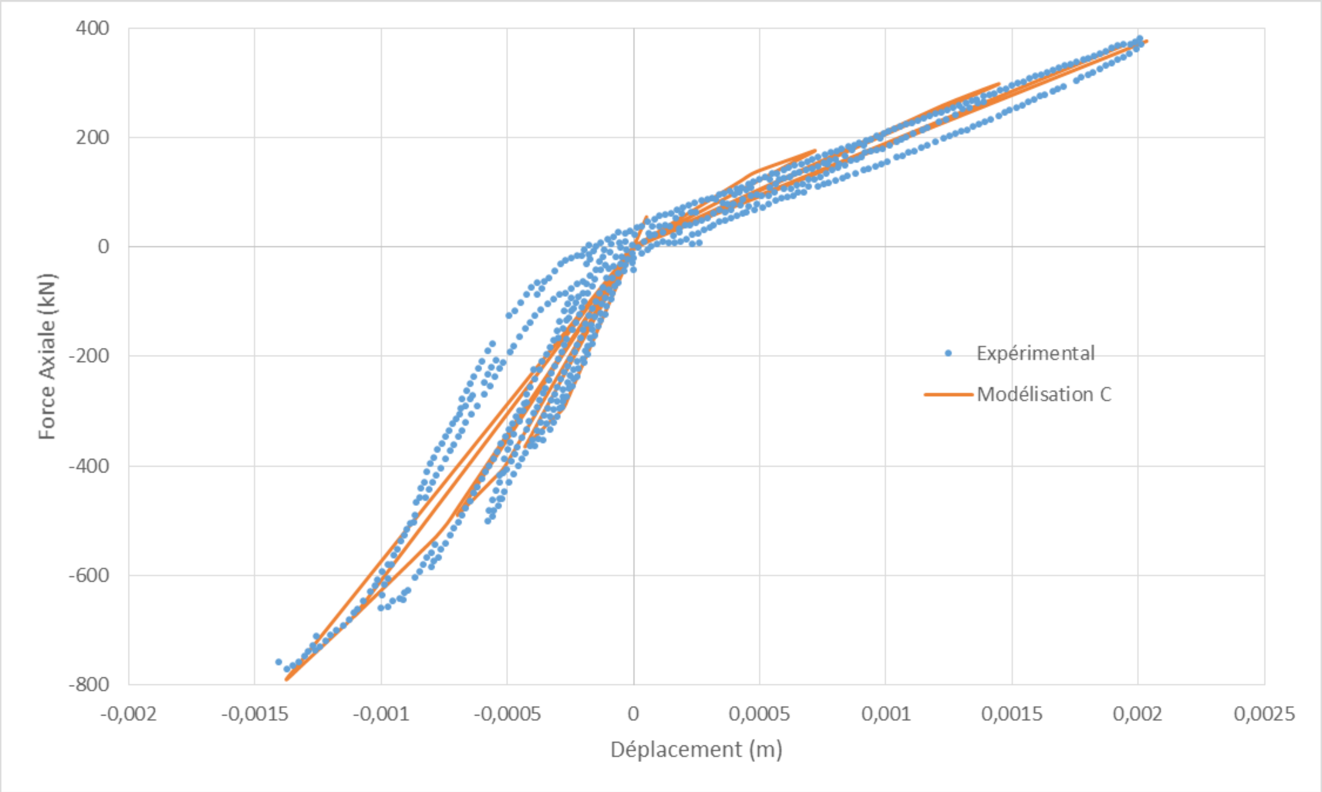

Figure 7: answer of modeling C

6 Summary of the results

The results of various modelings are compared with experimental measurements [1]. All the models make it possible satisfactorily to represent the dissymmetrical behavior of the beam in traction and compression. The elastic stiffnesses and post-rubber bands are correctly reproduced. The loops of hysteresis are less full because the models of behavior do not represent all the dissipative mechanisms of the material reinforced concrete.