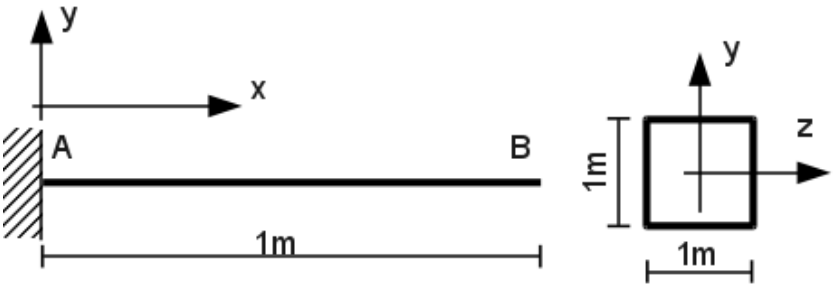
SSNL120 - Cyclic answer of laws of behavior of the concrete in 1D

Summary:
In this example one tests the model of behavior of the concrete of Mazars [R7.01.08] Dyears their version 1D using an element of beam multifibre [R3.08.08] under axial stress. The loading is composed of traction with loading and followed unloading by compression also with loading and unloading. It makes it possible to test resistances in traction and compression, to highlight the phenomena of refermeture of cracks and to test the unelastic deformations.

1 General characteristics

1.1 Geometry

Beam comforts length unit, of square section on side unit:



1.2 Material properties

Young modulus of the concrete: $E=3,727210^{10}Pa$
Resistance in traction of the concrete: $Rt=4.10^{6}Pa$
Resistance in compression of the concrete: $Rc=40.10^{6}Pa$

1.3 Boundary conditions

Embedding in A : $dx=dy=dz=0$ and $drx=dry=drz=0$.

1.4 Loadings

One decreases to grow and the axial deformation by imposing a displacement in B in the direction x . Two functions are defined, the first requests material in traction then in compression, the second requests material in cyclic loading.

Moments n°1	Deformation n°1	Moments n°2	Deformation n°2
0	0,00E+00	0	0,00E+00
1	1,40E-04	1	1,40E-04
2	5,00E-05	2	-4,00E-03
3	1,00E-03	3	1,00E-03
4	-4,00E-03	4	-5,00E-03
5	-2,00E-03		
6	-5,00E-03		
7	0,00E+00		

2 Reference solution

For modeling b: the reference solution is the uniaxial answer of the law of behavior of Mazars for the parameters selected materials. This solution is analytical.

3 Bibliography

[1] GHAVAMIAN HS., MAZARS J.: Strategy of calculations simplified for the analysis of the behavior of the reinforced concrete structures: code EFICOS. French review of civil engineer 1998; 2: 61 - 90.

4 Modeling B

4.1 Characteristics of modeling

Longitudinal grid of the beam: 2 nodes and 1 element (POU_D_EM).
The concrete part of the cross section of the beam is with a grid by 4 fibres.

Note:

The problem ESt 1D , Uonly fibre could not seem sufficient, but that would result in having worthless terms in the matrix of rigidity (the own inertia of fibres not being taken into account) and with an error at the time of the solution of the system of equations.

The concrete is modelled with the model of damage of MAZARS in version 1D [R7.01.08]. The parameters material used are the following:

Elasticity part:

$E = 3.72720\text{E+10}\ Pa$, $NU = 2.0\text{E-01}$

Non-linear part:

$AC = 1.71202987\text{E+00}$, $BC = 2.01163780\text{E+03}$, $BT = 1.21892353\text{E+04}$,
$BETA = 1.10\text{E+00}$, $AT = 7.00\text{E-01}$, $EPSD0 = 8.20396008\text{E-05}$,
$SIGM\_ELS = 35.0\text{E+06}\ Pa$, $EPSI\_ELU = 3.5\text{E-03}$

That corresponds to a concrete with:

- a constraint peak of compression of 40.963MPa, corresponding to a deformation peak of 1.75754E-03 .
- a constraint peak of traction of 3.05778MPa

4.2 Sizes tested and results

The 2 loadings are tested.
The figures below give the answers in constraints and deformations to the 2 loadings.

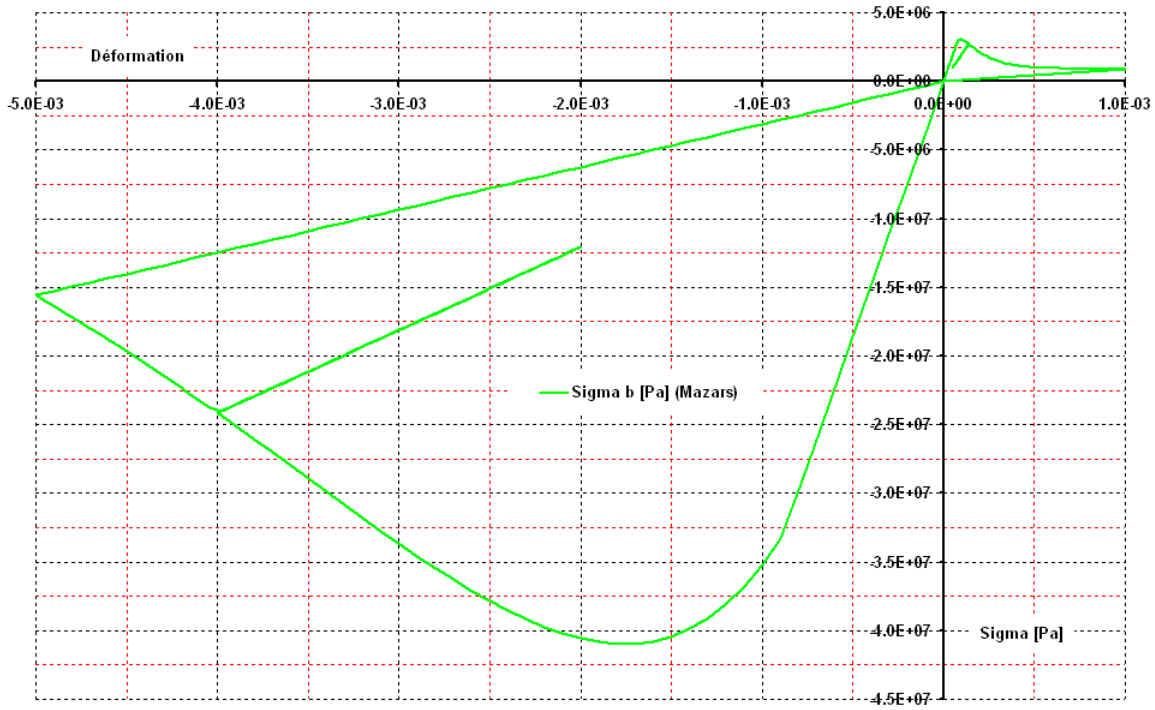


Figure 4.2-a : Evolution constraint according to the deformation, loading n°1.

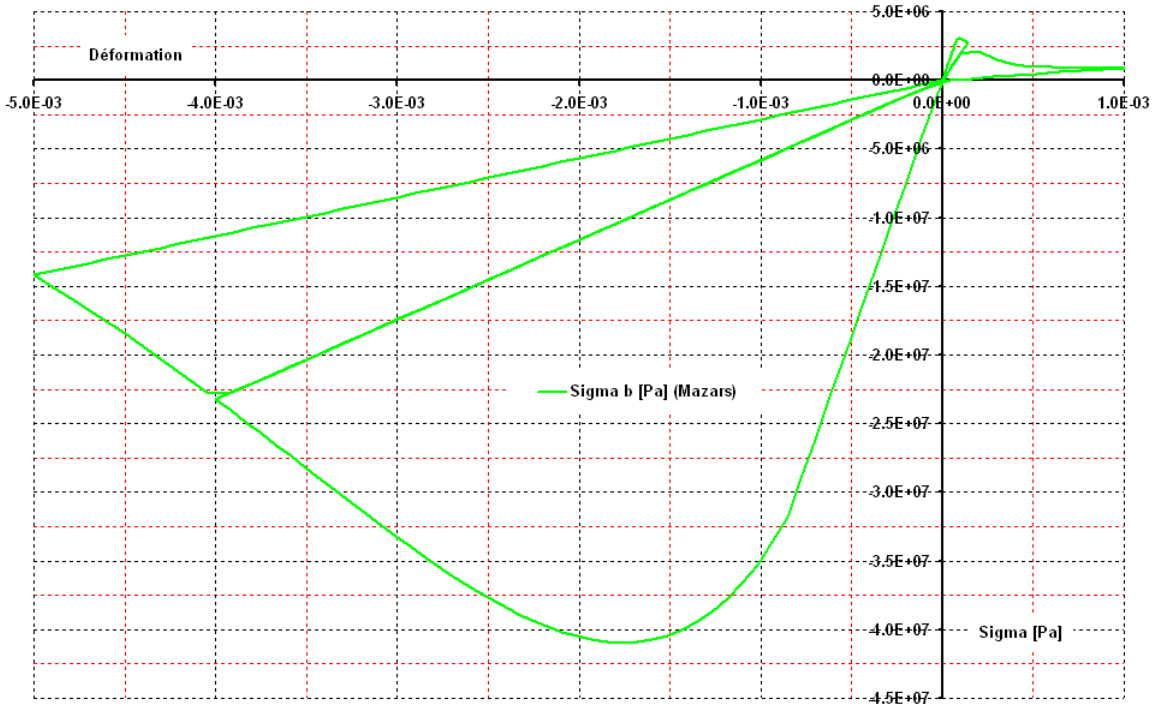


Figure 4.2-b : Evolution constraint according to deformation, loading n°2.

The figures below give the evolutions of the damages.

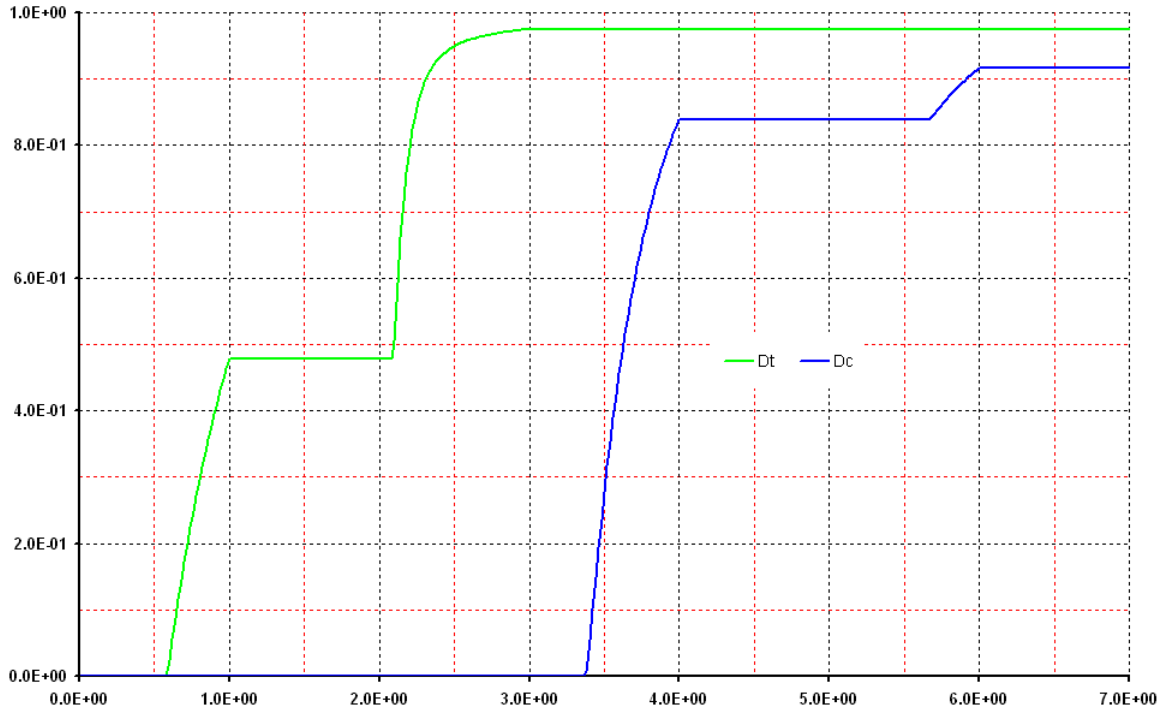


Figure 4.2-c : Evolution damages, loading n°1.

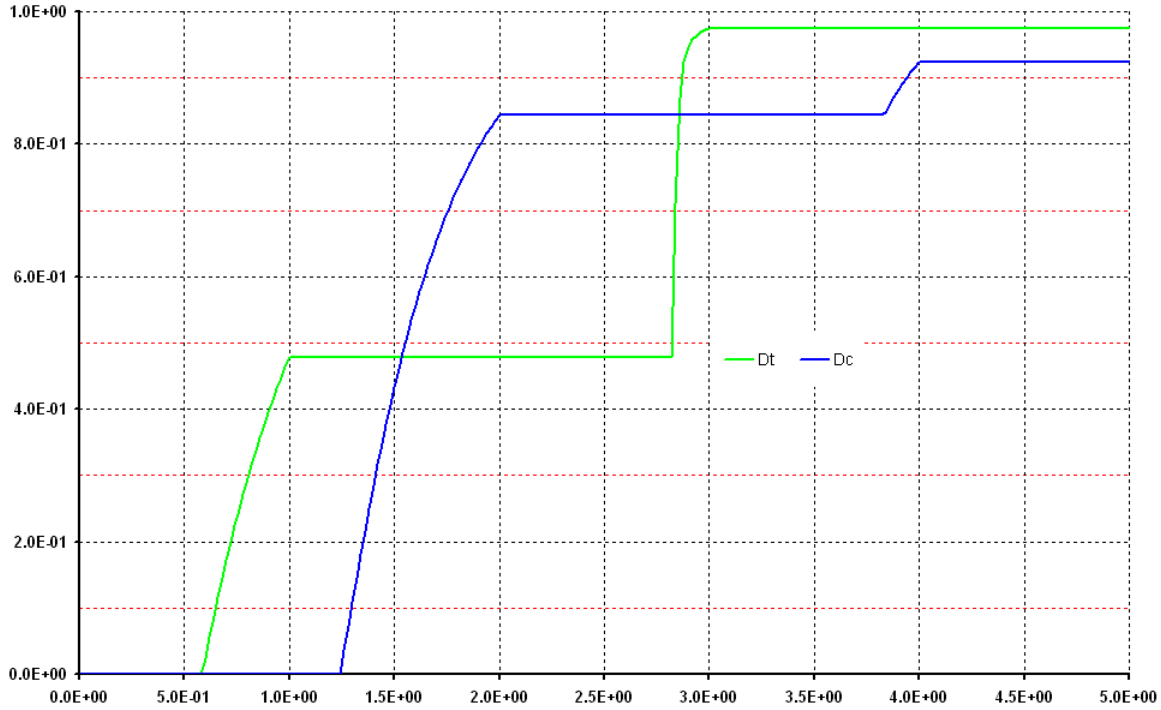


Figure 4.2-d : Evolution damages, loading n° 2.

The table below gives for several moments the constraint, the damage of traction and compression, for the loading n°1. These values are analytical.

Moment	Size	Standard Reference	Reference	Tolerance
0,60	SIXX	ANALYTICAL	3.0572E+06	1,00E-04
0,60	Dt	ANALYTICAL	2.3500E-02	2,00E-03
0,60	Cd.	ANALYTICAL	0.0000E+00	2,00E-03
1,00	SIXX	ANALYTICAL	2.7195E+06	1,00E-04
1,00	Dt	ANALYTICAL	4.7880E-01	2,00E-03
1,00	Cd.	ANALYTICAL	0.0000E+00	2,00E-03
2,00	SIXX	ANALYTICAL	9.7120E+05	1,00E-04
2,00	Dt	ANALYTICAL	4.7880E-01	2,00E-03
2,00	Cd.	ANALYTICAL	0.0000E+00	2,00E-03
2,10	SIXX	ANALYTICAL	2.6735E+06	1,00E-04
2,10	Dt	ANALYTICAL	5.0530E-01	2,00E-03
2,10	Cd.	ANALYTICAL	0.0000E+00	2,00E-03
3,00	SIXX	ANALYTICAL	9.1770E+05	1,00E-04
3,00	Dt	ANALYTICAL	9.7540E-01	2,00E-03
3,00	Cd.	ANALYTICAL	0.0000E+00	2,00E-03
0,00	SIXX	ANALYTICAL	-4.0949E+07	1,00E-04
3,56	Dt	ANALYTICAL	9.7540E-01	2,00E-03
3,56	Cd.	ANALYTICAL	3.8960E-01	2,00E-03
4,00	SIXX	ANALYTICAL	-2.3220E+07	1,00E-04
4,00	Dt	ANALYTICAL	9.7540E-01	2,00E-03
4,00	Cd.	ANALYTICAL	8.4430E-01	2,00E-03
5,00	SIXX	ANALYTICAL	-1.1610E+07	1,00E-04
5,00	Dt	ANALYTICAL	9.7540E-01	2,00E-03
5,00	Cd.	ANALYTICAL	8.4430E-01	2,00E-03
5,68	SIXX	ANALYTICAL	-2.2827E+07	1,00E-04
5,68	Dt	ANALYTICAL	9.7540E-01	2,00E-03
5,68	Cd.	ANALYTICAL	8.4840E-01	2,00E-03
6,00	SIXX	ANALYTICAL	-1.4181E+07	1,00E-04
6,00	Dt	ANALYTICAL	9.7540E-01	2,00E-03
6,00	Cd.	ANALYTICAL	9.2390E-01	2,00E-03

The table below gives for several moments criterion ELS, the loading n°1. These values are analytical.

Moment	Size	Standard Reference	Reference	Tolerance
0,60	V1 = CRITELS	ANALYTICAL	0,00000	2.00000E-03
1,00	V1 = CRITELS	ANALYTICAL	0,00000	2.00000E-03
2,00	V1 = CRITELS	ANALYTICAL	0,00000	2.00000E-03
2,10	V1 = CRITELS	ANALYTICAL	0,00000	2.00000E-03
3,00	V1 = CRITELS	ANALYTICAL	0,00000	2.00000E-03
3,56	V1 = CRITELS	ANALYTICAL	1,16997	2.00000E-03
4,00	V1 = CRITELS	ANALYTICAL	0,66344	2.00000E-03
5,00	V1 = CRITELS	ANALYTICAL	0,33172	2.00000E-03
5,68	V1 = CRITELS	ANALYTICAL	0,65220	2.00000E-03
6,00	V1 = CRITELS	ANALYTICAL	0,40517	2.00000E-03

The table below gives for several moment S L E ELECTED criterion, for the loading n°1. These values are analytical.

Moment	Size	Standard Reference	Reference	Tolerance
1.00	V2 = CRITELU	ANALYTICAL	0,00000	2.00000E-03
2..00	V2 = CRITELU	ANALYTICAL	0,00000	2.00000E-03
3..00	V2 = CRITELU	ANALYTICAL	0,00000	2.00000E-03
4..00	V2 = CRITELU	ANALYTICAL	1,14286	2.00000E-03
4..00	V2 = CRITELU	ANALYTICAL	0,57143	2.00000E-03
6..00	V2 = CRITELU	ANALYTICAL	1,42857	2.00000E-03
7..00	V2 = CRITELU	ANALYTICAL	0,00000	2.00000E-03

The table below gives for several moments the constraint, the damage of traction and compression, for the loading n°2. These values are analytical.

Moment	Size	Standard Reference	Reference	Tolerance
1,00	SIXX	ANALYTICAL	2.7195E+06	1,00E-04
1,00	Dt	ANALYTICAL	4.7880E-01	2,00E-03
1,00	Cd.	ANALYTICAL	0.0000E+00	2,00E-03
2,00	SIXX	ANALYTICAL	-2.3220E+07	1,00E-04
2,00	Dt	ANALYTICAL	4.7880E-01	2,00E-03
2,00	Cd.	ANALYTICAL	8.4430E-01	2,00E-03
3,00	SIXX	ANALYTICAL	9.1770E+05	1,00E-04
3,00	Dt	ANALYTICAL	9.7540E-01	2,00E-03
3,00	Cd.	ANALYTICAL	8.4430E-01	2,00E-03
4,00	SIXX	ANALYTICAL	-1.4181E+07	1,00E-04
4,00	Dt	ANALYTICAL	9.7540E-01	2,00E-03
4,00	Cd.	ANALYTICAL	9.2390E-01	2,00E-03

The table below gives for several moment S L E criterion ELS, for the loading n° 2. These values are analytical.

Moment	Size	Standard Reference	Reference	Tolerance
1,00	V1 = CRITELS	ANALYTICAL	0,00000	1.00000E-04
2,00	V1 = CRITELS	ANALYTICAL	0,66344	1.00000E-04
3,00	V1 = CRITELS	ANALYTICAL	0,00000	1.00000E-04
4,00	V1 = CRITELS	ANALYTICAL	0,40517	1.00000E-04

The table below gives for several moment S L E criterion EL U, for the loading n° 2. These values are analytical.

Moment	Size	Standard Reference	Reference	Tolerance
1,00	V2 = CRITELU	ANALYTICAL	0,00000	2.00000E-03
2,00	V2 = CRITELU	ANALYTICAL	1,14286	2.00000E-03
3,00	V2 = CRITELU	ANALYTICAL	0,00000	2.00000E-03
4,00	V2 = CRITELU	ANALYTICAL	1,42857	2.00000E-03

5 Summary of the results

For modeling B, the results are in very good agreement with the analytical values.