SSNL122 - Cantilever beam Multifibre subjected to a Summarized

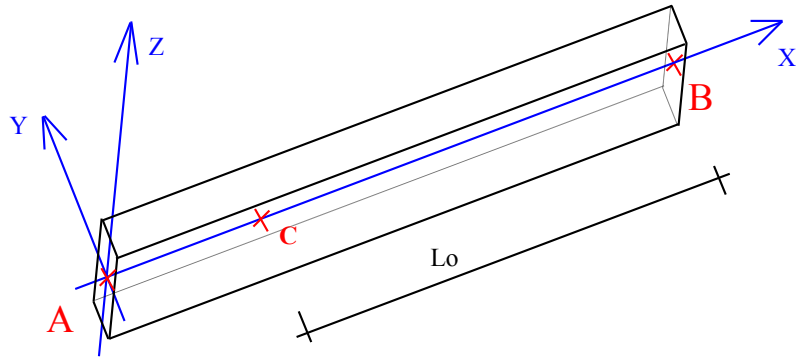
force:

This test relates to the validation of beam multifibre with a modelization in POU_D_TGM.

This problem makes it possible to test:
- linear finite elements of beams type with a modelization in POU_D_TGM,
- the taking into account of the directional sense,
- the computation of the SIEF_ELGA and the EFGE_ELNO.

1 Problem of reference

1.1 Geometry



Length of the bar: $3\mathrm{m}$
Fixed support in A
Forces in B

Section of the bar:
height: $0.04\mathrm{m}$
width: $0.02\mathrm{m}$

1.2 Properties of the material

Material to elastoplastic behavior with a linear hardening, for the linear element:
Elasticity:

- Young modulus $E=2.1\mathrm{E}+11\ Pa$

Plasticity:

- slope of curve of tension in the plastic range $\mathrm{d\_sigm\_epsi}=1.0\mathrm{E}+08\ Pa$
- yield stress $sy=400.0\mathrm{E}+06\ Pa$

1.3 Boundary conditions and loadings

At the point A , perfect fixed support (blocking of displacements and rotations),

- blocking of the degrees of freedom: DX , DY , DZ , DRX , DRY , DRZ .
- Loading with point: B $F=(F_x, F_y, F_z)$.

2 Quantities and

2.1 result reference solution of reference

Marks with arrows while B following Z

$$\delta_z = \frac{F_z . L^3}{2 E I_y}$$

Deflection while B following Y

$$\delta_y = \frac{F_y . L^3}{2 E I_z}$$

Forced in a point C of coordinates (v_y, v_z) of the section of the beam

$$\sigma = \frac{N}{S} + \frac{M_y}{I_y} . v_z - \frac{M_z}{I_z} . v_y$$

with $M_z = +F_y . Lo$, $M_y = -F_z . Lo$

from where:

$$\sigma = \frac{N}{S} - \frac{3 E Lo}{L^3} (\delta_y v_y + \delta_z v_z) \quad \text{[éq2.1-1]}$$

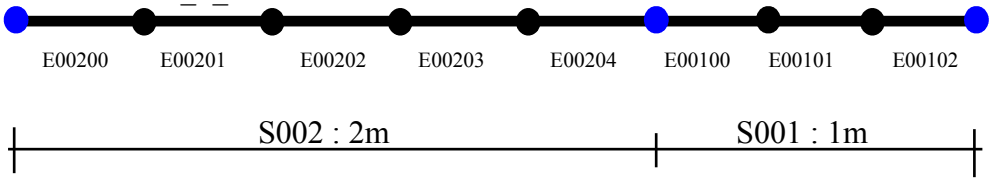
2.2 Bibliographical reference

[“M7-01-72 Project. Behavior elastoplastic of the beams. New approach.” Note HM77/01/140/A.

3 Modelization A

3.1 Characteristic of the modelization and linear

mesh Element: POU_D_TGM.



Mechanical characteristics of the section (homogeneous units to meters):

A	IY	IZ	AY	AZ	JX	JG
8.0e-04	2.666667e-08	1.066667e-07	1.191790e+00	1.172840e+00	7.093682e-08	1.438125e-12

Loading at the point B .

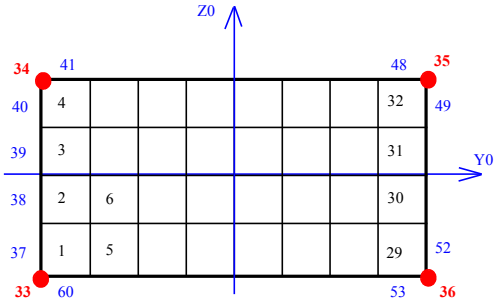
	Fx	Fy	Fz
Time 1	80 000 N	-150N	-200N
Time 2	80 000 N	-280N	-400N

At time 1 the section remains elastic, at time 2 the section is partially plasticized.

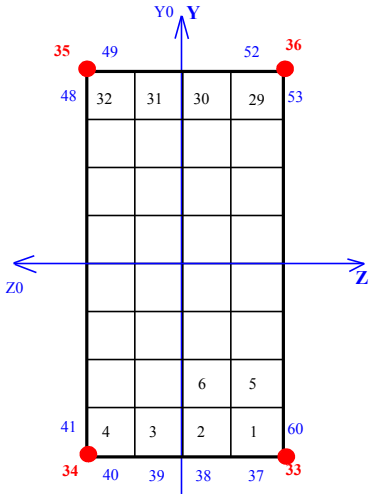
3.2 Classification of fibers

the principal reference of inertia $(Y0, Z0)$ of the beam must be turned of 90° so that the strongest inertia IZ is along the axis Y of the total reference. The goal is to test of the command key key ORIENTATION AFFE_CARA_ELEM.

In the local coordinate system of the beam



In the total reference of study



Several “types” of fibers are used:

- fibers whose numbers go from 1 to 32. They are affected of a non-zero area in the command file,
- fibers whose numbers are 33,34,35,36. They are located at the 4 corners of the section. These fibers, in the command file, are affected of a section equal to zero. They are used only for postprocessing,
- fibers whose numbers go from 37 to 60. They are located on edge external of the section. These fibers, in the command file, are affected of a section equal to zero. They are used only for postprocessing.

3.3 Quantities tested and results

the quantities tested and analyzed are them:

- SIEF_ELGA, at the first Gauss point of the element E00200 . It is the Gauss point more close to the fixed support $Lo=2.95491933\text{m}$.
- EFGE_ELNO, with the 2 nodes of the element E00200 . The node G00202 is the point of rigid support ($Lo=3.0\text{m}$), the node I00200 is with $Lo=2.6\text{m}$.

3.3.1 Behavior elastic

Stresses at the Gauss point: SIEF_ELGA

the stresses calculated by the equation [éq 2.1-1] and by *Code_Aster* are given in the two tables below (values in MPa). The provision of the tables takes again the diagram of provision of fibers in the total reference. The most requested fiber is the n°36 with a stress of 390 MPa .

Stresses calculated in fibers by the equation [éq 2.1-1]

35	80.16			346.3	
21	66.15			331.3	
-7	37.12			303.3	
	9	98.18			320.-
		70.15			291.-
		42.13			263.-
-120	-75	13.10			235
-148	-103	-15	74.16		
-176	-131	-43	46.13		
-190	-146	-57	32.12		

Forced calculated in fibers by *Code_Aster*.

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the relative error between two computations is given in the table below. Whatever the fiber, it remains lower than 0.1% .

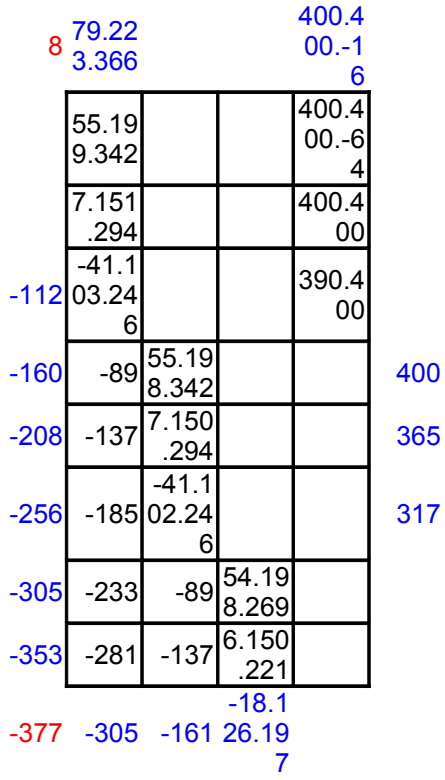
-0.022%	-0.013%	-0.009%	-0.008%	-0.007%	-0.007%
-0.026%	-0.012%	-0.009%	-0.008%	-0.007%	-0.007%
0.014%	-0.010%	-0.007%	-0.006%	-0.006%	-0.006%
-0.010%	0.010%	-0.004%	-0.005%	-0.005%	-0.005%
-0.013%	-0.029%	0.000%	-0.003%	-0.004%	-0.004%
-0.014%	-0.021%	0.012%	0.000%	-0.002%	-0.003%
-0.014%	-0.019%	0.069%	0.004%	-0.001%	-0.002%
-0.015%	-0.018%	-0.094%	0.012%	0.002%	0.000%
-0.015%	-0.018%	-0.043%	0.029%	0.006%	0.003%
-0.015%	-0.018%	-0.036%	0.049%	0.009%	0.005%

Nodal stresses: EFGE_ELNO
the stresses calculated by the equation [éq 2.1-1] and by *Code_Aster* are given in table below (values in MPa)

Analytical	Node	*Code_Aster*	Error relative
G00202	SIMAX = 394.307	SIMAX = 394.276	-0.008%
	SIMIN = -194.307	SIMIN = -194.276	-0.016%
I00200	SIMAX = 355.066	SIMAX = 355.057	-0.002%
	SIMIN = -155.066	SIMIN = -155.057	-0.006%

3.3.2 Behavior plastic

Stresses to the Gauss point: SIEF_ELGA
the table below gives the values of the stresses, after plasticization partial of the section, obtained with *Code_Aster*. The behavior of the material is elastoplastic “almost perfect”, the hardening slope is weak. The maximum stress, which is beyond the yield stress, thus remains very close to the elastic threshold to 400MPa .



This computation is carried out for the test of non regression of *Code_Aster*.

Nodal stresses: EFGE_ELNO
the table below gives the values of the nodal stresses, after plasticization partial of the section, obtained with *Code_Aster*. These values are interpolated by *Code_Aster* starting from THE SIEF_ELGA. The behavior of the material is elastoplastic “almost perfect”, the hardening slope is weak. The maximum stress, which is beyond the yield stress, thus remains very close to the elastic threshold to 400MPa .

Node	*Code_Aster*
G00202	SIMAX = 400.091
	SIMIN = -385.441
I00200	SIMAX = 400.053

SIMIN = -306.905

This computation is carried out for the test of non regression of *Code_Aster*.

4 Summary of the results

This case test shows the good performance of a modelization of the behavior of the beams by an approach multifibre.