

SSNL122 - Multifibre beam cantilever subjected with an effort

Summary:

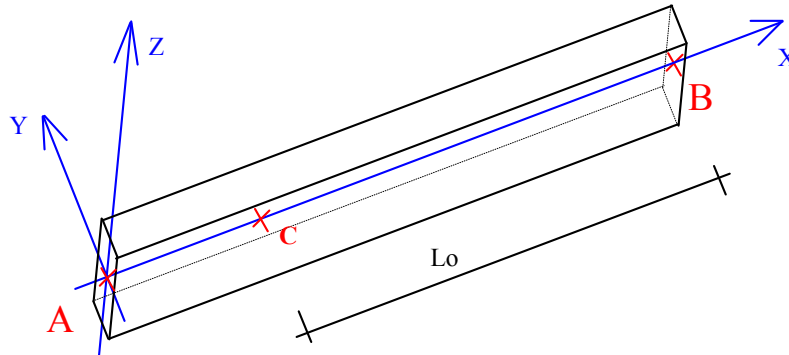
This test relates to the multifibre validation of beam with a modeling in `POU_D_TGM`.

This problem makes it possible to test:

- linear finite elements of beams type with a modeling in `POU_D_TGM`,
- the taking into account of the orientation,
- the calculation of `SIEF_ELGA` and of `EFGE_ELNO`.

1 Problem of reference

1.1 Geometry



Length of the bar: 3m
Embedding in A
Forces in B

Section of the bar:
height: 0.04m
width: 0.02m

1.2 Properties of material

Material with elastoplastic behaviour with a linear work hardening, for the linear element:

Elasticity:

- Young modulus $E = 2.1E+11 Pa$

Plasticity:

- slope of the traction diagram in the plastic range $d_sigm_epsi = 1.0E+08 Pa$
- yield stress $s_y = 400.0E+06 Pa$

1.3 Boundary conditions and loadings

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

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

2 Reference solution

2.1 Sizes and results of reference

Arrow in B according to Z

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

Arrow in B according to Y

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

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

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

$$\text{with } \begin{cases} M_z = +F_y \cdot L_o \\ M_y = -F_z \cdot L_o \end{cases}$$

from where:

$$\sigma = \frac{N}{S} - \frac{3 E L_o}{L^3} (\delta_y v_y + \delta_z v_z) \quad [\text{éq 2.1-1}]$$

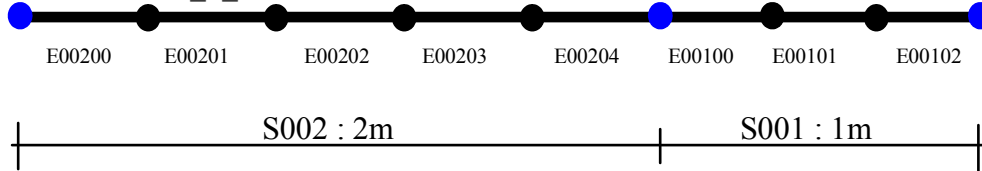
2.2 Bibliographical reference

[1] "M7-01-72 project. Elastoplastic behavior of the beams. New approach." Note HM77/01/140/A.

3 Modeling A

3.1 Characteristics of modeling and the grid

Linear 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 .

	F_x	F_y	F_z
Moment 1	80 000 N	-150N	-200N
Moment 2	80 000 N	-280N	-400N

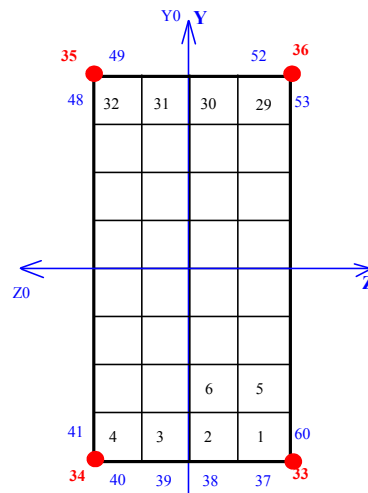
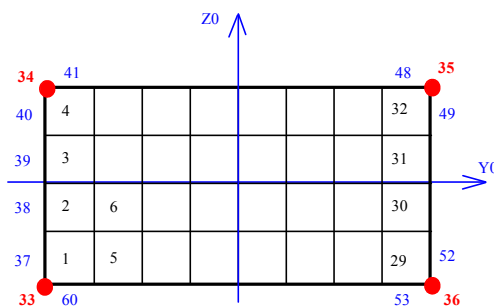
At moment 1 the section remains elastic, at moment 2 the section is partially plasticized.

3.2 Classification of fibres

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

In the local reference mark of the beam

In the total reference mark of study



Several "types" of fibres are used:

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

3.3 Sizes tested and results

The size tested and analyzed is SIEF_ELGA, at the first point of Gauss of the element E00200 . It is the point of Gauss more close to embedding, $L_0 = 2.95491933\text{m}$.

3.3.1 Elastic behavior

Constraints at the point of Gauss: SIEF_ELGA

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

Constraints calculated in
fibres by the equation [éq 2.1-1]

35	80	168	257	346	390
21	66	154	243	331	376
-7	37	126	215	303	348
-35	9	98	187	275	320
-63	-19	70	158	247	291
-91	-47	42	130	219	263
-120	-75	13	102	191	235
-148	-103	-15	74	163	207
-176	-131	-43	46	134	179
-190	-146	-57	32	120	165

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The relative error between two calculations is given in the table below. Whatever the fibre, it remains lower than 0.095% .

-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%

3.3.2 Plastic behavior

Constraints at the point of Gauss: SIEF_ELGA

The table below gives the values of the constraints, after plasticization partial of the section, obtained with *Code_Aster*. The behavior of material is elastoplastic "almost perfect", the slope of work hardening is weak. The maximum constraint, which is beyond the yield stress, thus remains very close to the elastic threshold to 400MPa .

8	79	223	366	400	400
-16	55	199	342	400	400
-64	7	151	294	400	400
-112	-41	103	246	390	400
-160	-89	55	198	342	400
-208	-137	7	150	294	365
-256	-185	-41	102	246	317
-305	-233	-89	54	198	269
-353	-281	-137	6	150	221
-377	-305	-161	-18	126	197

This calculation is carried out for the test of nonregression of *Code_Aster*.

4 Summary of the results

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