# SSNL122 - Multifibre beam cantilever subjected with an effort

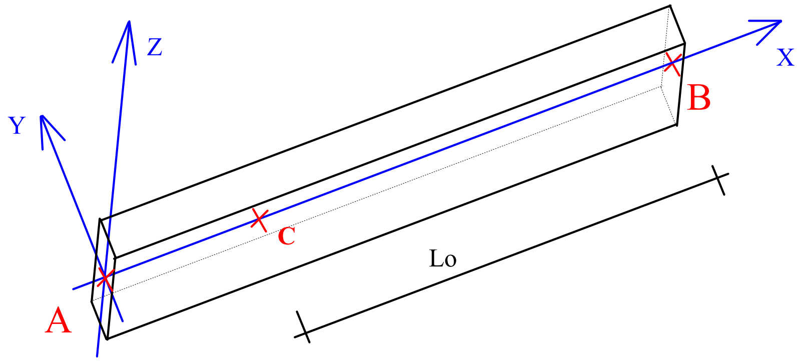
**Summary:**

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: $3\text{m}$
Embedding in $A$
Forces in $B$

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

## 1.2 Properties of material

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

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

Plasticity:

- slope of the traction diagram in the plastic range $\text{d\_sigm\_epsi}=1.0\text{E}+08\,Pa$
- yield stress $sy=400.0\text{E}+06\ Pa$

## 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 $Z$

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

Arrow in $B$ according to $Y$

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

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

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

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

from where:

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

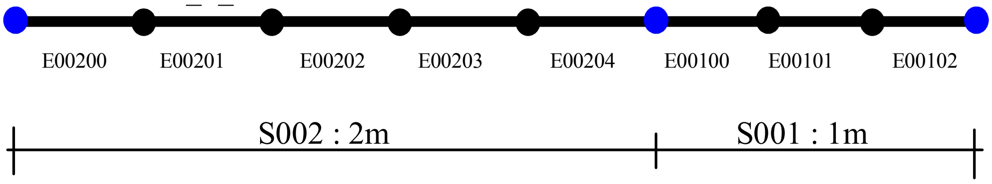
## 2.2 Bibliographical reference

[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 $B$ .

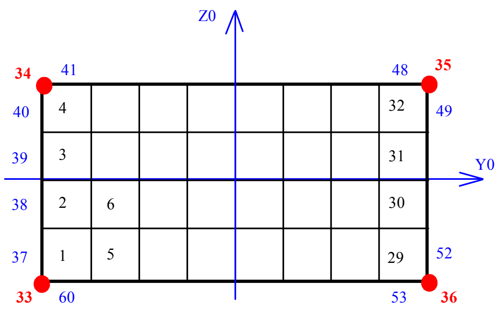
| | $Fx$ | $Fy$ | $Fz$ |
|---|---|---|---|
| Moment 1 | $80\,000\,\mathrm{N}$ | $-150\mathrm{N}$ | $-200\mathrm{N}$ |
| Moment 2 | $80\,000\,\mathrm{N}$ | $-280\mathrm{N}$ | $-400\mathrm{N}$ |

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

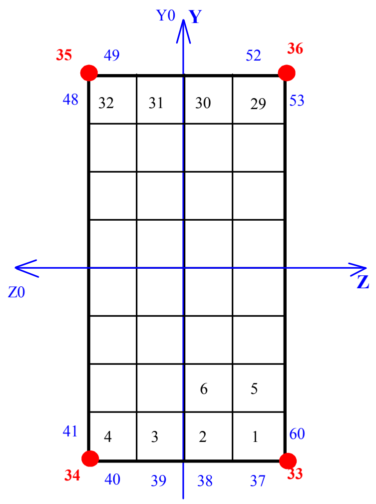
## 3.2 Classification of fibres

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 $\mathrm{E00200}$. It is the point of Gauss more close to embedding, $Lo=2.95491933\mathrm{m}$.

### 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 $\mathrm{MPa}$). 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 $390\ \mathrm{MPa}$.

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 |

Constraints calculated in fibres by *Code_Aster*.

| | | | | | |
|---|---|---|---|---|---|
| 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 |

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 $400\mathrm{MPa}$ .

| | | | | | |
|---|---|---|---|---|---|
| 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.