SSNL141 - P multifibre and multimatériaux goatskin bottles

Summary:

The objective this test is to validate the use of multimatériaux section for the multifibre beams.
The beam consists of two materials.

Two types of calculation are made:

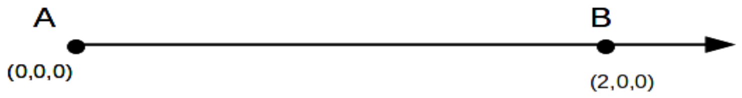
- a static calculation
- two modal calculations, one with the option `MASS_MECA` and the other with the option `MASS_MECA_DIAG`

The reference solutions result from the theory of the beams of Euler.

1 Problem of reference

1.1 Geometry

A beam length is considered $2\,m$ directed according to X .



1.2 Characteristics of section

1.2.1 Geometry and fibres

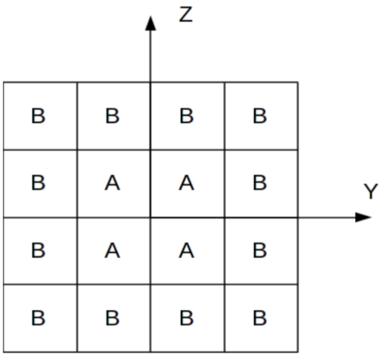
The section considered is a square of $10\,cm$ on side. It is made up of 16 fibres, themselves of form square.

1.2.2 Materials

The section comprises two different materials which are described in the following table.

Material	**Concrete**	**Steel**
Young modulus	$3\times10^{10}\,Pa$	$2\times10^{11}\,Pa$
Poisson's ratio	0.2	0.0
Density	$2500\,kg/m^3$	$7850\,kg/m^3$
Symbol on the figure	B	A

The materials are affected on fibres like illustrates it the figure which follows:



This structure has the advantage keeping the centers of rigidity, gravity, torsion confused at the origin of the local reference mark of the section and of being symmetrical compared to its center and compared to the axes Y and Z .

1.3 Loadings

1.3.1 Boundary conditions

Static calculation:
The node A is embedded and the node B is left free.

Modal calculation:
Displacements of the node A are blocked as well as rotation around the axis of the beam.
Displacements in Y and in Z node B are blocked as well as rotation around the axis of the beam.

1.3.2 Forces applied

Static calculation:
A force distributed constant of $-1.0\text{E}+04\,N/m$ according to Z is applied to the beam.

Modal calculation:
None.

2 Reference solution

2.1 Static calculation: fixed beam

The theory of the beams working in inflection provides a value of reference for maximum displacement. For a beam fixed at an end and free of the other under loading distributed, maximum displacement at the loose lead called marks with arrows, is given by:

$$f=\frac{-qL^4}{8\mathrm{EI}_{eq}}$$

- q : the force divided into N/m .
- L : the length of the beam in m .
- EI_{eq} : in the case mono-material it is the product of the Young modulus and the quadratic moment.

In the multimatériaux case, and with the configuration described herebefore, EI_{eq} is calculated as follows:

$$EI_{eq}=\int_S E(s)z(s)^2 ds$$

In *Code_Aster* this calculation is approached by a sum on fibres:

$$EI_{eq}=\sum_{i=1}^{nb_{fibres}} E_i z_i^2 A_i$$

where z_i is the coordinates according to Z center of fibre i and where A_i is its surface.

2.2 Modal calculation: beam in simple support

For a beam in simple support, such as defined in the paragraph 1.3.1, the theory of the beams provided of the values of reference for the Eigen frequency of modal calculation.

The first Eigen frequency is: $f_1=\frac{\pi}{2L^2}\sqrt{\frac{EI_{eq}}{m}}$.

where L is the length of the beam and m is the linear density of the beam.

2.3 Uncertainties on the solution

None.

3 Modeling A

3.1 Characteristics of modeling

The elements of beams are modelled by POU_D_TGM.

3.2 Characteristics of the grid

The grid consists of 10 meshs SEG2 of the same length.

3.3 Sizes tested and results

3.3.1 Static calculation: fixed beam

Arrow with the node B .

Node	Field	Component	**Value of reference**	**Tolerance (%)**
B	DEPL	DZ	$-6.64935064935E-2$	0.5

3.3.2 Modal calculation: beam on simple support

Calculation of the 1st Eigen frequency.

NUME_ORDRE	PARA	**Value of reference**	**Tolerance (%)**
1	FREQ	34.7665079762	0.5

4 Modeling B

4.1 Characteristics of modeling

The elements of beams are modelled by POU_D_EM.

4.2 Characteristics of the grid

The grid consists of 10 meshs SEG2 of the same length.

4.3 Sizes tested and results

4.3.1 Static calculation: fixed beam

Arrow with the node B.

Node	Field	Component	**Value of reference**	**Tolerance (%)**
B	DEPL	DZ	$-6.64935064935E-2$	0.1

4.3.2 Modal calculation: beam on simple support

Calculation of the 1st Eigen frequency.

NUME_ORDRE	PARA	**Value of reference**	**Tolerance (%)**
1	FREQ	34.7665079762	0.1

5 Summary of the results

The calculated results are extremely theoretical solution for static calculation and modal calculation. That validates the use of POU_D_TGM and of POU_D_EM out of multi-materials.