SSNL141 – beams multifibre and multimatériaux

Abstract:

The purpose of this test is to validate the use of multimatériaux section for the multifibre beams. The beam consists of two materials divided into checkerwork on the section.

Two types of computation are made:

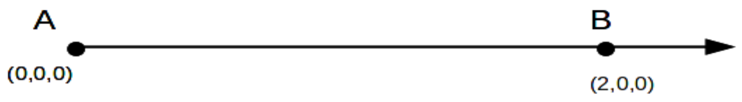
- a static computation
- a modal computation

the reference solutions result from the theory of the beams of Eulerian.

1 Problem of reference

1.1 Geometry

One considers a beam length $2m$ directed according to X .



1.2 Characteristics of section

1.2.1 Geometry and fibers

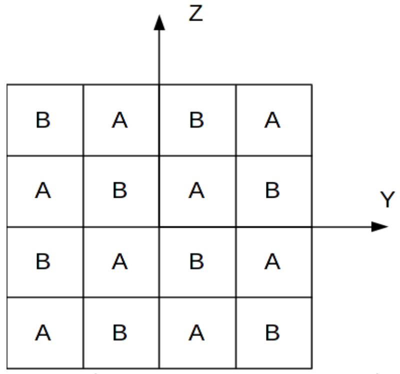
the section considered is a square on $10\,cm$ side. It is made up of 16 fibers, themselves of form square.

1.2.2 Materials

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

Concrete material		Steel
Modulus Young	$3\times 10^{10}\,Pa$	$2\times 10^{11}\,Pa$
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 fibers like illustrates it the figure which follows:



This structure has the advantage of keeping the centers of stiffness, gravity, torsion confused at the origin of the local coordinate system of the section.

1.3 Loadings

1.3.1 Boundary conditions

static Computation:
The node A is embedded and the node B is left free.

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

1.3.2 Applied forces

static Computation:
A constant distributed force of $-1.0\mathrm{E}+06\,N/m$ according to Z is applied to the beam.

Modal computation:
None.

2 Static reference solution

2.1 Computation: clamped beam

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

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

- q : the distributed force in 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 computation is approached by a sum on fibers:

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

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

2.2 Modal computation: beam out of simple bearing

For a beam out of simple bearing, such as defined in the paragraph 2, the theory of the beams provided of the values of reference for the Eigen frequency of modal computation.

The first eigenfrequency 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 Modelization A

3.1 Characteristic of the modelization

the beam elements are modelled by POU_D_TGM.

3.2 Characteristics of the mesh

The mesh consists of 10 meshes of the same SEG2 length.

3.3 Quantities tested and static

3.3.1 Computation results: clamped beam

Marks with arrows with the node B .

Node	Field	Component	**Value of reference**	**Tolerance (%)**
B	DEPL	DZ	-2.2260869565217392	3.0

3.3.2 Modal computation: beam on bearing simple

Computation of the 1st eigenfrequency.

NUME_ORDRE	PARA	**Value of reference**	**Tolerance (%)**
1	FREQ	51.742647217688024	1.5

4 Modelization B

4.1 Characteristic of the modelization

the beam elements are modelled by POU_D_EM.

4.2 Characteristics of the mesh

The mesh consists of 10 meshes of the same SEG2 length.

4.3 Quantities tested and static

4.3.1 Computation results: clamped beam

Marks with arrows with the node B .

Node	Field	Component	**Value of reference**	**Tolerance (%)**
B	DEPL	DZ	−2.2260869565217392	2.5

4.3.2 Modal computation: beam on bearing simple

Computation of the 1st eigenfrequency.

NUME_ORDRE	PARA	**Value of reference**	**Tolerance (%)**
1	FREQ	51.742647217688024	8.0

5 Summary of the results

the variations to the values of reference resulting from the theory of the beams are sufficiently weak to validate the use of multimatériaux for `the POU_D_TGM`.