SSLL118 – Clamped beam subjected to the displacements defined in a Summarized

local coordinate system:

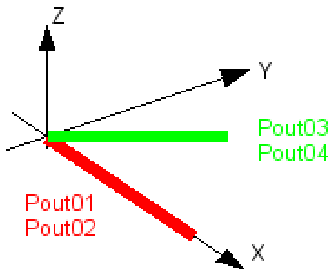
This case test makes it possible of the command to validate THE OPTION DDL_POUTRE AFFE_CHAR_MECA, which makes it possible to impose the displacements defined in a local coordinate system related to the beam.

The conditions on the degrees of freedom $(dx, dy, dz, drx, dry, drz)$ expressed in the local coordinate system are translated into conditions on the degrees of freedom $(DX, DY, DZ, DRX, DRY, DRZ)$ expressed in the total reference.

This case test in particular makes it possible to validate the fact, that to impose a null displacement in a local coordinate system is correctly translated in the total reference.

1 Problems of reference

1.1 Geometry



There are 4 beams length L modelled with POU_D_E.

$Pout01$ $Pout02$: they are along the total axis X.
$Pout03$ $Pout04$: their axis is in the direction $(1.0, 1.0, 0.0)$.

1.2 Properties of the material

Characteristic of the material
$E=2.0\mathrm{E}11\mathrm{Pa}$ $\nu=0.30$

1.3 geometrical Characteristics

All the beams have the same rectangular section:
$HY=0.2$ $HZ=0.1$
The length of the beams is of $2\mathrm{m}$.

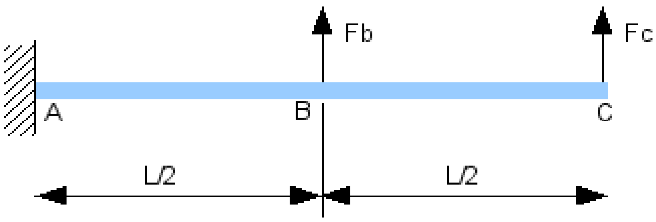
1.4 Boundary conditions and loadings

All the beams are embedded in the beginning: nodes $N1, N2, N3, N4$.
A displacement is imposed at the other end: nodes NA, NB, NC, ND.
A force can be imposed on the medium node: nodes IA, IB, IC, ID.

2 Reference solution

2.1 Method of calculating

the reference solution uses the results below:



δc and δb represent displacement at the points C and B.

$$EI.\delta c=\frac{Fc.L}{3}+\frac{5.Fb.L^3}{48} \quad [1]$$

$$EI.\delta b=\frac{5.Fc.L^3}{47}+\frac{Fb.L^3}{24} \quad [2]$$

the reaction of bearing $Fa=-Fc-Fb$ [3]

the boundary conditions which is used during the validation are: a displacement in C : δc and a possible force in B : Fb. The resolution of the equations [1], [2], [3] give the following statements:

$$\delta b=\frac{7.Fb.L^3}{768.EI}+\frac{5.\delta c}{16}$$

$$Fc=\frac{3.\delta c.EI}{L^3}-\frac{5.Fb}{16}$$

$$Fa=-\frac{3.\delta c.EI}{L^3}-\frac{11.\mathrm{Fb}}{16}$$

2.2 Quantities and results of reference

the computations carried out on the 4 beams differ either by boundary conditions imposed on their nodes B and C, or by a definition different from the local coordinate system. The boundary conditions imposed in displacement or force make it possible to determine the theoretical solutions of the various cases considered.

Characteristics of beam:

$$3.EIy=10\mathrm{E}{+}07\,N.m^2 \qquad 3.\mathrm{EIz}=4.0\mathrm{E}+07\,N.m^2$$

Name of beam: $Pout01$

Data:

VECT_Y	:	$(-0.0\ \ 1.0\ \ 0.0)$
δy in C (in the local coordinate system)	:	$2.0\mathrm{E}-03\,m$
δz in C (in the local coordinate system)	:	$1.0\mathrm{E}-03\,m$

Theoretical results:

FY in A (in the total reference)	:	$\frac{-3.\delta y.EIz}{L^3}$

FZ in A (in the total reference) : $\dfrac{-3.\delta z.EIy}{L^3}$

Name of beam: $Pout02$
Data:
VECT_Y : $(-0.0 \ \ 0.0 \ \ 1.0)$
δy in C (in the local coordinate system) : $2.0\text{E}-03\,m$
δz in C (in the local coordinate system) : $1.0\text{E}-03\,m$
Theoretical results:

FY in A (in the total reference) : $\dfrac{3.\delta z.EIz}{L^3}$

FZ in A (in the total reference) : $\dfrac{-3.\delta y.EIy}{L^3}$

Name of beam: $Pout03$
Data:
VECT_Y : $(-1.0 \ \ 1.0 \ \ 0.0)$
δy in C (in the local coordinate system) : $2.0\text{E}-03\,m$
δz in C (in the local coordinate system) : $1.0\text{E}-03\,m$
Theoretical results:

FX in A (in the total reference) : $\dfrac{-3\sqrt{2}.\delta y.EIz}{2.\text{L}^3}$

FY in A (in the total reference) : $\dfrac{3\sqrt{2}.\delta y.EIz}{2.L^3}$

FZ in A (in the total reference) : $\dfrac{-3.\delta z.EIy}{L^3}$

Name of beam: $Pout04$
Data:
VECT_Y : $(-1.0 \ \ 1.0 \ \ 0.0)$
δy in C (in the local coordinate system) : $2.0\text{E}-03\,m$
δz in C (in the local coordinate system) : 0
FZ in B (in the total reference) : 1000.0
Theoretical results:

FX in A (in the total reference) : $\dfrac{-3\sqrt{2}.\delta y.EIz}{2.\text{L}^3}$

FY in A (in the total reference) : $\dfrac{-3\sqrt{2}.\delta y.EIz}{2.\text{L}^3}$

FZ in A (in the total reference) : $\dfrac{-11.Fb}{16}$

DZ in B (in the total reference) : $\dfrac{7.Fb.L^3}{768.EI}$

3 Modelization A

3.1 Characteristic of the mesh and the modelization

Many nodes : 12
Many SEG2 : 8
Number of mesh group : The 4

beams are modelled with POU_D_E.

3.2 Quantities tested and results

the quantities tested are the reactions to the fixed support and the displacement of the node ID .

Standard	beam of the field	Component	Node	Values of reference	Relative Error
$Pout01$	FORC_NODA	DY	$N1$	-10000.0	0.0%
		DZ	$N1$	-1250.0	0.0%
$Pout02$	FORC_NODA	DY	$N2$	5000.0	0.0%
		DZ	$N2$	-2500.0	0.0%
$Pout03$	FORC_NODA	DX	$N3$	7071.0678	1.34E- 05%
		DY	$N3$	-7071.0678	1.34E- 05%
		DZ	$N3$	-1250.0	1.32E- 05%
$Pout04$	FORC_NODA	DX	$N4$	7071.0678	1.34E- 05%
		DY	$N4$	-7071.0678	1.34E- 05%
		DZ	$N4$	-687.5	5.79E- 06%
	DEPL	DZ	ID	2.1875E-05	-1.93E- 05%

4 Modelization B

4.1 Characteristic of the mesh and the modelization

Many nodes : 16
Number of SEG2 : 12
Number of mesh group : The 6

beams are modelled with POU_D_E.

4.2 Quantities tested and results

the quantities tested are the reactions to the fixed support and the displacement of the node ID .

Standard	beam of the field	Standard	Comp onent	Node of Reference	Values of reference	Tolerance
$Pout01$	FORC_NODA	DY	$N1$	"ANALYTIQUE"	-10000.0	0,1%
		DZ	$N1$	"ANALYTIQUE"	-1250.0	0,1%
$Pout02$	FORC_NODA	DY	$N2$	"ANALYTIQUE"	5000.0	0,1%
		DZ	$N2$	"ANALYTIQUE"	-2500.0	0,1%
$Pout03$	FORC_NODA	DX	$N3$	"ANALYTIQUE"	7071.0678	0,1%
		DY	$N3$	"ANALYTIQUE"	-7071.0678	0,1%
		DZ	$N3$	"ANALYTIQUE"	1250.0	0,1%
$Pout04$	FORC_NODA	DX	$N4$	"ANALYTIQUE"	7071.0678	0,1%
		DY	$N4$	"ANALYTIQUE"	-7071.0678	0,1%
		DZ	$N4$	"ANALYTIQUE"	-687.5	0,1%
	DEPL	DZ	ID	"ANALYTIQUE"	2.1875E-05	0,1%

4.3 Remarks

This modelization makes it possible to validate OF THE COMMAND DDL_POUTRE AFFE_CHAR_MECA with the key word MAILLE/GROUP_MA, the beams $Pout01$, $Pout02$, $Pout03$, $Pout04$ were lengthened of 1m.

The place of application of the boundary conditions and the loadings did not change.

5 Summary of the results

This case test makes it possible to validate the use of DDL_POUTRE of the command AFFE_CHAR_MECA. One validates in particular the fact that to impose a null displacement in a local coordinate system is correctly translated in the total reference.