SDLL01 - Short beam on simple bearings

Abstract:

This two-dimensional problem consists in searching the frequencies of vibration of a mechanical structure made up of a beam out of simple bearings at its two ends. This case test of Structural mechanics corresponds to a dynamic analysis of a linear model having a linear behavior. One compared to the studies the influence of the position of the points considered as fulcrums (points on neutral fiber or points offset at the base of the beam) neutral fiber of a thick beam.

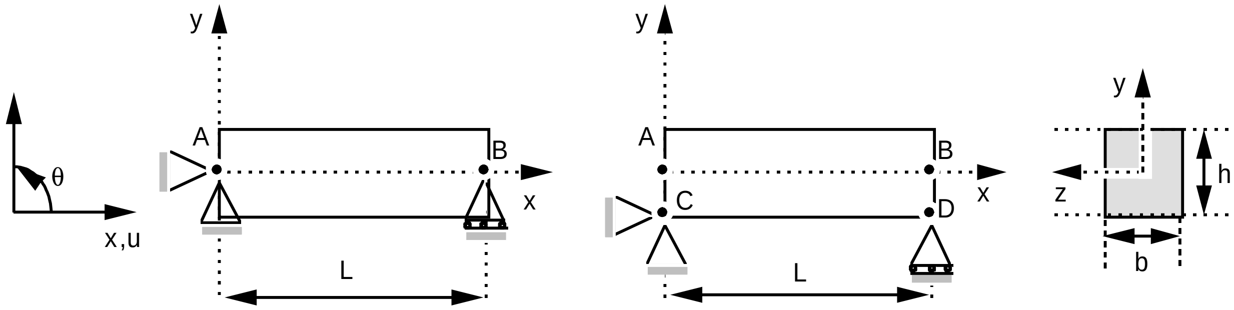
This test makes it possible to test part of the features which relate to the beams of Timoshenko, rigid connections and the search for eigenfrequencies by inverse iterations.

The results got with the fulcrums on neutral fiber, is with the offset fulcrums are compared with analytical computations on the beams of TImoshenko. The results got with the offset fulcrums are compared with results of NON-regression.

When the fulcrums are offset, one observes a coupling between the various modes of tension - compression and bending.

1 Problem of reference

1.1 rectangular



Geometry Cross-section:

height:	$h=0.2\,m$
width:	$b=0.1\,m$
area:	$A=2.10^{-2}\,m^2$
inertia:	$Iz=6.667\,10^{-5}$
shears:	$Ay=Az=1.17692$
torsion:	$Jx=0.45776042\,10^{-4}$

Length of the beam

$L=1.\,m$

Coordinated of the points (m) **:**

	A	B	C	D
x	0.	1.	0.	1.
y	0.	0.	– 0.1	– 0.1

1.2 Material properties

$E=2.10^{11}\,Pa$

$\nu=0.3$

$\rho=7800.\,kg/m^3$

1.3 Boundary conditions and loadings

Problem 1:	Not A	$u=v=0.$	Not B	$v=0.$
Problem 2:	Not C	$u=v=0.$	Not D	$v=0.$

2 Reference solution

2.1 Method of calculating used for the reference solution

the reference solution is that given in the book of Timoshenko on the theory of vibrations of the beams and plates ([1]):

Problem 1: Analytical computation

the equation of bending of the nonslender beams gives the formulation of Timoshenko, by superimposing the effects of the pure bending, the shear deformations and the inertia of rotation.

The eigenfrequencies in traction and compression are given according to this theory by:

$$f_i=\frac{\lambda_i}{2\pi L}\sqrt{\frac{E}{\rho}} \text{ with } \lambda_i=\frac{(2i-1)}{2}\pi \quad i=1,2,\ldots$$

One finds in the reference [1] an equivalent formula for the modes of bending.

Problem 2:

The problem not having an analytical solution, the solution is established by results of NON-regression.

The modes of bending and traction and compression are coupled.

2.2 Results of reference

Problem 1: the first 6 eigen modes.

Problem 2: the first 5 eigen modes.

2.3 Uncertainty on the solution

Problem 1: analytical solution. “

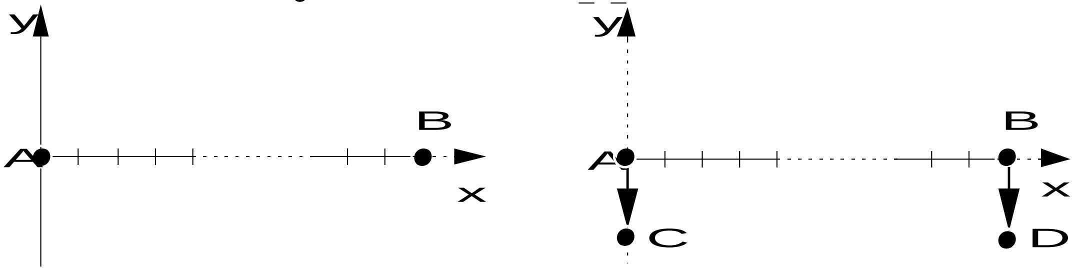
2.4 Bibliographical References

[1] S.P. TIMOSHENKO, D.H. YOUNG, W. WEAVER. Vibrations Problems in Engineering. New - York: Wiley & Sounds, 4° edition, p. 415 (1974).

3 Modelization A

3.1 Characteristic of the modelization

One uses the beam element right of Timoshenko: `POU_D_T`



Problem 1:

Cutting: beam: AB 40 meshes limiting
SEG2 Conditions:
in all the nodes `DDL_IMPO = (GROUP_NO = "AB", DZ=0., DRX=0, DRY=0.)`
in A : `(NOEUD=' A", DX=0., D=0. )`
in B : `(NOEUD=' B', DY=0. )`

Problem 2:

Cutting: beam: AB 40 meshes rigid
SEG2 2 elements AC BC : 2 meshes limiting
SEG2 Conditions:
in all the nodes `DDL_IMPO = (TOUT=' OUI', DZ=0., DRX=0, DRY=0.)`
in C : `(NOEUD=' IT, DX=0., DY=0. )`
in D : `(NOEUD=' OF, DY=0. )`

Names of the nodes: Not A = $N100$ Not C = $N300$
Not B = $N200$ Not D = $N400$

3.2 Characteristic of the mesh

Many nodes: 43
Number of meshes and types: 42 `SEG2`

3.3 Remarks

Definition of the rigid beams AC and BD :

Section: $Hy=0.2$ $Hz=0.2$.
Material: $E=2.10^{16}$ $\rho=0$.

3.4 Quantities tested and Frequency

results (Hz)

Eigen mode	Reference	*Aster*	tolerance
Problem 1			
bending 1	431.555	431.8916	0.2%
tension 1	1265.924	1266.0056	0.2%
bending 2	1498.295	1500.7635	0.2%
bending 3	2870.661	2873.5344	0.2%
tension 2	3797.773	3799.9692	0.2%
bending 4	4377.837	4370.8206	0.2%

Eigen mode	Reference	*Aster*	tolerance
Problem 2			
1	392.8	394.4774	0.5%
coupling 2	922.2	922.6072	0.1%
bending 3	1592.0	1638.2311	3%
tension 4	2629.2	2778.7000	5.8%
compression 5	3126.2	3261.6699	4.5%

One calculates the kinetic energy of the first beam element connected to the point A of problem 1:

Component	option	Reference (NON_REGRESSION)	*Aster*	% TOTAL
difference	ECIN_ELEM	51366.0	51366.027	1%

3.5 Remarks

Computations carried out by:

Problem 1:

```
MODE_ITER_INV  OPTION=' AJUSTE' LIST_FREQ=  (430. , 4500. )
```

Problem 2:

```
MODE_ITER_INV  OPTION=' AJUSTE' LIST_FREQ=  (380. , 3300. )
```

Contents of the file results:

Problem 1:

the first 6 eigenfrequencies, modal eigenvectors and parameters.

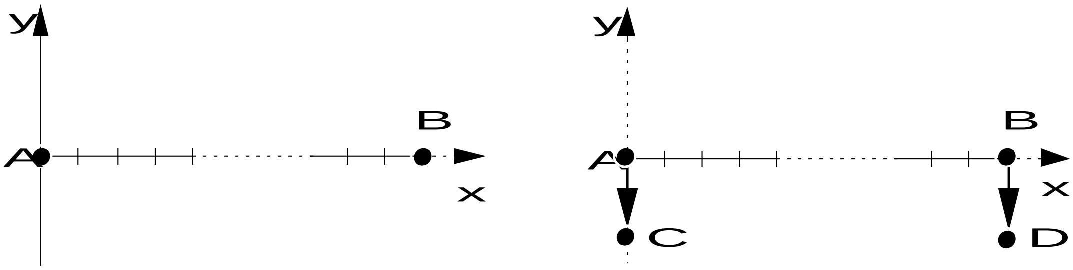
Problem 1:

the first 5 eigenfrequencies, modal eigenvectors and parameters.

4 Modelization B

4.1 Characteristic of modelization

POU_D_TG



Problem 1:

Cutting:	beam: AB 40 meshes `limiting`
SEG2 Conditions:	
in all the nodes	`DDL_IMPO = (GROUP_NO=' AB', DZ=0., DRX=0, DRY=0.)`
in A :	`(GROUP_NO=' A'   DX=0., DY=0. )`
in B :	`(GROUP_NO=' B',   DY=0. )`

Problem 2:

Cutting:	beam AB: 40 meshes `rigid` SEG2 2 elements AC BD : 2 meshes `limiting`
SEG2 Conditions:	
in all the nodes	`DDL_IMPO = (TOUT=' OUI', DZ=0., DRX=0, DRY=0.)`
in C :	`(GROUP_NO=' IT,   DX=0., DY=0. )`
in D :	`(GROUP_NO=' OF,   DY=0. )`
Names of the nodes:	Not A = $N100$ Not C = $N300$ Not B = $N200$ Not D = $N400$

4.2 Characteristic of the mesh

Many nodes: 43
Number of meshes and types: 42 `SEG2`

4.3 Remarks

Definition of the rigid beams AC and BD :

Section: $Hy=0.2$ $Hz=0.2$.
Material: $E=2.10^{16}$ $\rho=0$.

4.4 Quantities tested and Frequency

results (Hz)

Eigen mode	Reference		*Aster*	tolerance
Problem 1				
bending 1	431.555		431.8916	0.2%
tension 1	1265.924		1266.0056	0.2%
bending 2	1498.295		1500.7635	0.2%
bending 3	2870.661		2873.5344	0.2%
tension 2	3797.773		3799.9692	0.2%
bending 4	4377.837		4370.8206	0.2%
Problem 2				
1	392.8	± 2.7%	394.4774	0.5%
coupling 2	922.2	± 5.7%	922.6072	0.1%
bending 3	1592.0	± 2.9%	1638.2311	3%
tension 4	2629.2	± 5.7%	2778.7000	5.8%
compression 5	3126.2	± 4.3%	3261.6699	4.5%

4.5 Remarks

Computations carried out by:

Problem 1:

```
ITERATIONS_INVERSESOPTION  : LIST_FREQ “ADJUSTS”: (430. , 4500. )
```

Problem 2:

```
ITERATIONS_INVERSESOPTION  : LIST_FREQ “ADJUSTS”: (380. , 3300. )
```

Contents of the file results:

Problem 1:

the first 6 eigenfrequencies, modal eigenvectors and parameters.

Problem 1:

the first 5 eigenfrequencies, modal eigenvectors and parameters.

5 Summary of the

results the problem without eccentricity is correctly treated. That with eccentricity is validated only by NON-regression.