SDLS504 - Side buckling of a beam (discharge)

Summary:

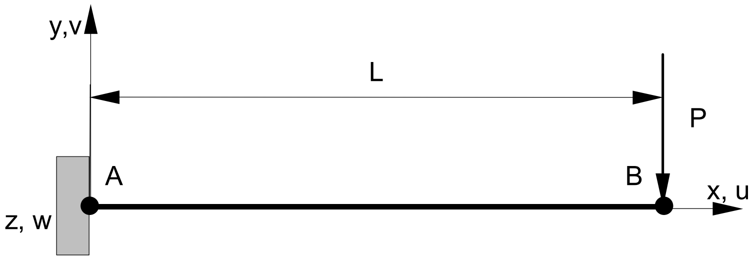
This test represents a calculation of stability of a beam (IPE) comforts subjected to a bending stress at an end. One calculates the critical load leading to elastic buckling by discharge. The geometrical matrix of rigidity used in the resolution of the problem to the eigenvalues is that which is due to the initial constraints.

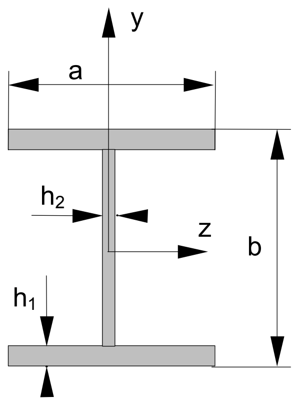
This test makes it possible to validate modeling finite elements COQUE_3D with the meshs TRIA7 and QUAD9 in the field of the linear buckling of Euler.

The critical load and the associated clean mode are compared with an analytical reference solution.

1 Problem of reference

1.1 Geometry





L = 2 m			$A = 3.3645\ 10^{-3}\ m^2$
a = 0.09m			$I_y = 1.3792\ 10^{-6}\ m^4$
b = 0.2 m			$I_z = 2.1617\ 10^{-5}\ m^4$
h_1 = 0.0113 m			$J = 1.0894\ 10^{-7}\ m^4$
h_2 = 0.0075 m			

1.2 Properties of material

The properties of material constituting the plate are:

$E=2.10^{11}\,Pa$ Young modulus
$\nu=0.3$ Poisson's ratio

1.3 Boundary conditions and loadings

- Embedding at the point A
- A force is applied $P=-104\,797.82\,N$ at the point B corresponding to the critical load data in [bib1]

1.4 Initial conditions

Without object

2 Reference solution

2.1 Method of calculating used for the reference solution

The calculation of the critical load of discharge is given in detail in [bib1].

$P_{cr}=\gamma_2 \frac{\sqrt{E I_y C}}{L^2}$	critical load of discharge
with $C=GJ$	torsional rigidity
$J=((b-2h_1)h_2^3+2a h_1^3)$	constant of torsion [bib2]
$C_1 E I_y \frac{b^2}{2}$	rigidity with warping corresponding to a beam in `I`

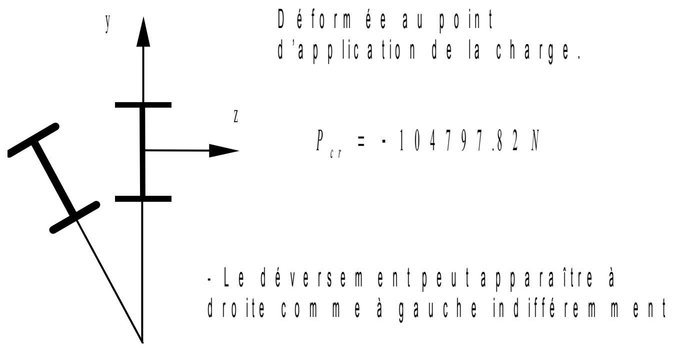
Digital application:

$$C=8578.515\, N.m^2$$
$$C1=5516.8\, N.m^4$$
$$\frac{L^2 C}{C_1}=6.22$$

The value of γ_2 depends on the report $\frac{L^2 C}{C_1}$. In our case γ_2 is worth 8,617. This value is extracted from a table given in [bib1]. What gives us $P_{cr}=104797.82\, N$

2.2 Results of reference

Critical load of discharge and associated mode.



2.3 Uncertainties on the solution

Analytical solution

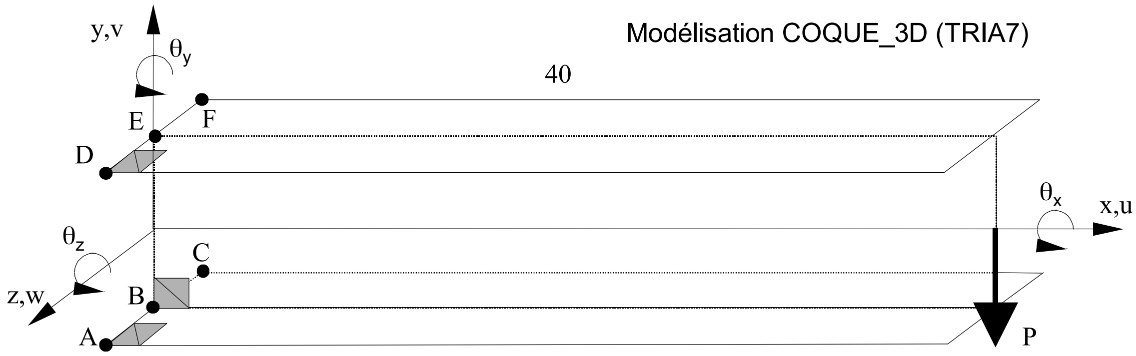
2.4 Bibliographical references

1) S.P. TIMOSHENKO, J.M. MANAGES: Theory of elastic stability, second edition, DUNOD 1966.

2) S.P. TIMOSHENKO: Resistance of materials, Volume 2: DUNOD 1968.

3 Modeling A

3.1 Characteristics of modeling



Découpage :
- cotés AB, BC, DE, EF 2 éléments
- coté EB 4 éléments

Conditions aux limites :
- cotés AB, BC, DE, EF et EB :
$u = v = w = \theta_x = \theta_y = \theta_z = 0$

3.2 Characteristics of the grid

Many nodes: 3022
Many meshs and types: 960 TRIA7

3.3 Sizes tested and results

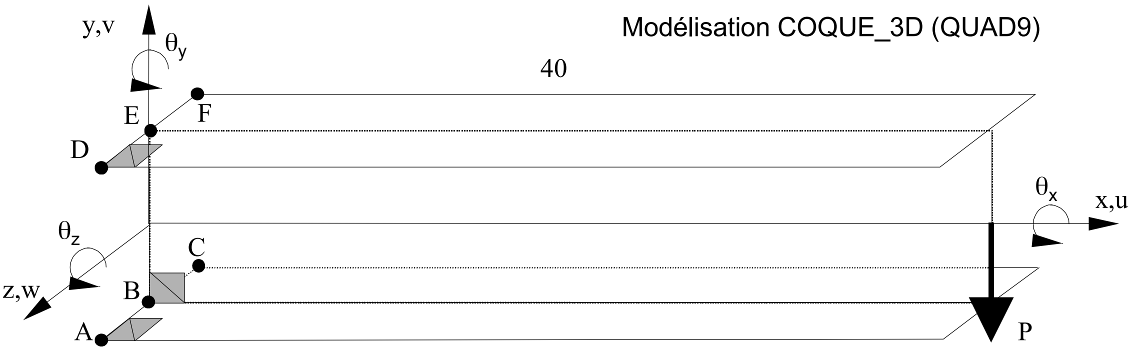
Identification	Moments	Reference	*Aster*	% difference
Critical load (mode 1)		104 797.82 NR	107 753.49	2,820
Critical load (mode 2)		– 104 797.82 NR	– 107 878.78	2,940

3.4 Remarks

The two critical loads obtained are similar in amplitude, but of contrary sign. The associated modes of discharge are identical. In this CAS-test, the critical load associated with the loading applied corresponds to the second found critical load (Mode 2).

4 Modeling B

4.1 Characteristics of modeling



Découpage :
- cotés AB, BC, DE, EF 2 éléments
- coté EB 4 éléments

Conditions aux limites :
- cotés AB, BC, DE, EF et EB :
$u = v = w = \theta_x = \theta_y = \theta_z = 0$

4.2 Characteristics of the grid

Many nodes: 2106
Many meshs and types: 480 `QUAD9`

4.3 Sizes tested and results

Identification	Moments	Reference	*Aster*	% difference
Critical load (mode 1)		– 104 797.82 NR	– 97 636.39	– 6,834
Critical load (mode 2)		104 797.82 NR	97 636.39	– 6,834

4.4 Remarks

The two critical loads obtained are similar in amplitude, but of contrary sign. The associated modes of discharge are identical. In this CAS-test, the critical load associated with the loading applied corresponds to the first found critical load (Mode 1).

5 Summary of the results

For each modeling, one obtains two similar critical loads but of contrary sign. The associated modes of discharge are identical. The negative critical loads correspond to the loading applied while the positive critical loads correspond to the opposite loading. If one disregards sign of the loading both critical loads really exist.

The critical loads relating to the loading applied are correct. The errors obtained do not exceed:

- 3% for modeling COQUE_3D with meshs TRIA7,
- 7% for modeling COQUE_3D with meshs QUAD9.

It is noted that modeling COQUE_3D with meshs TRIA7 is more precise than modeling COQUE_3D with meshs QUAD9.

This test made it possible to test modeling COQUE_3D in linear buckling of Euler.