

## SSLL105 - Elastic buckling of a structure in L

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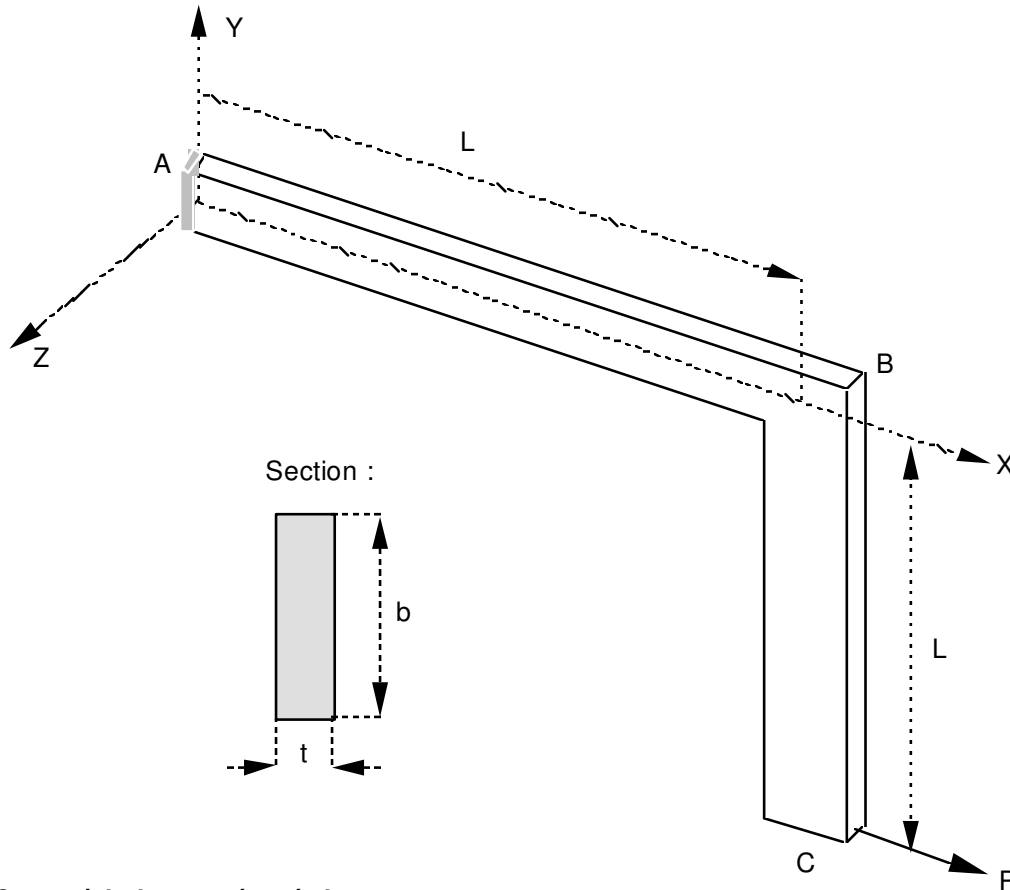
### Summary:

A structure in form of  $L$  composed of two slim beams of mean rectangular section is subjected to a force at an end, and is embedded at the other end. One seeks the critical loads of elastic buckling associated with the positive and negative values of the force. The field of the test is:

- Linear elastic mechanics,
- Buckling of beams and the hulls,
- The first 3 modelings are relative to (POU\_D\_E, POU\_D\_T, POU\_D\_TG).
- 4<sup>ème</sup> (POU\_D\_E) and 5<sup>ème</sup> (POU\_D\_TGM) modelings test the criterion of buckling in the nonlinear operator of statics.
- 5<sup>ème</sup> (COQUE\_3D: QUAD9) and 6<sup>ème</sup> (COQUE\_3D: TRIA7) modelings test the criterion of buckling in the nonlinear operator of statics.
- 7<sup>ème</sup> (DKT: QUAD4) and 8<sup>ème</sup> (DKT: TRIA3) modelings test the criterion of buckling in the nonlinear operator of statics.

## 1 Problem of reference

### 1.1 Geometry



Caractéristiques géométriques :

$$\begin{aligned} L &= 240 \text{ mm} \\ b &= 30 \text{ mm} \\ t &= 0.6 \text{ mm} \end{aligned}$$

### 1.2 Material properties

Young modulus:  $E = 71240 \text{ MPa}$

Poisson's ratio:  $\nu = 0.3$

### 1.3 Boundary conditions and loadings

- Boundary conditions: embedding in  $A$
- Loading:  $F = P_x$ 
  - case 1:  $P_x = -1 \text{ N}$
  - case 2:  $P_x = +1 \text{ N}$

## 2 Reference solution

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### 2.1 Method of calculating used for the reference solution

Average enters the results got with various codes (8 results in [bib1]).

### 2.2 Results of reference

Values of the critical load for the two loading cases.

### 2.3 Uncertainty on the solution

The maximum variation compared to the average of results used is of 2%. This value is thus associated with uncertainty relating to the value of reference.

### 2.4 Bibliographical references

- 1 G. DEVESA: Treatment of great displacements in the element of angle to 7 degrees of freedom established in *Code\_Aster*, validation by a classical case test (HM - 77/94/079).

## 3 Modeling A

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### 3.1 Characteristics of modeling

20 elements POU\_D\_E

### 3.2 Characteristics of the grid

Many nodes: 21  
Many meshes and types: 20 SEG2

### 3.3 Sizes tested and results

Loading case	Reference	Tolerance (%)
1	-1,088	0.19
2	- 0,680	0.19

## 4 Modeling B

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### 4.1 Characteristics of modeling

20 elements POU\_D\_T

### 4.2 Characteristics of the grid

Many nodes: 21

Many meshes and types: 20 SEG2

### 4.3 Sizes tested and results

Loading case	Reference	Tolerance (%)
1	-1,088	0.19
2	- 0,680	0.19

## 5 Modeling C

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### 5.1 Characteristics of modeling

20 elements POU\_D\_TG

### 5.2 Characteristics of the grid

Many nodes: 21  
Many meshes and types: 20 SEG2

### 5.3 Sizes tested and results

Loading case	Reference	Tolerance (%)
1	-1,088	0.35
2	-0,680	1.2

**Note:**

The results of this modeling differ slightly from the others and are identical to those obtained by calculation Aster of the reference [bib1].

## 6 Modeling D

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### 6.1 Characteristics of modeling

20 elements POU\_D\_E

### 6.2 Characteristics of the grid

Many nodes: 21  
Many meshes and types: 20 SEG2

### 6.3 Sizes tested and results

Loading case	Reference	Tolerance (%)
1	1,088	0,12
2	0,680	0,025

One tests also the management of the event '**INSTABILITY**' of **DEFI\_LIST\_INST**. More exactly this event occurs because the critical load factor crosses the value 1 and that must thus start the associated action, always definite under **DEFI\_LIST\_INST**.

As one wants to continue calculation in spite of this detected instability, one specifies:  
`ACTION = 'CONTINUES'`.

## 7 Modeling E

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### 7.1 Characteristics of modeling

20 elements POU\_D\_TGM

### 7.2 Characteristics of the grid

Many nodes: 21  
Many meshes and types: 20 SEG2

### 7.3 Characteristics of the grid of the transverse section (fibres)

Many fibres: 100  
Many meshes and types: 100 QUA4

### 7.4 Sizes tested and results

Loading case	Reference	Tolerance (%)
1	1,088	0,184
2	0,680	1,471

**Note:**

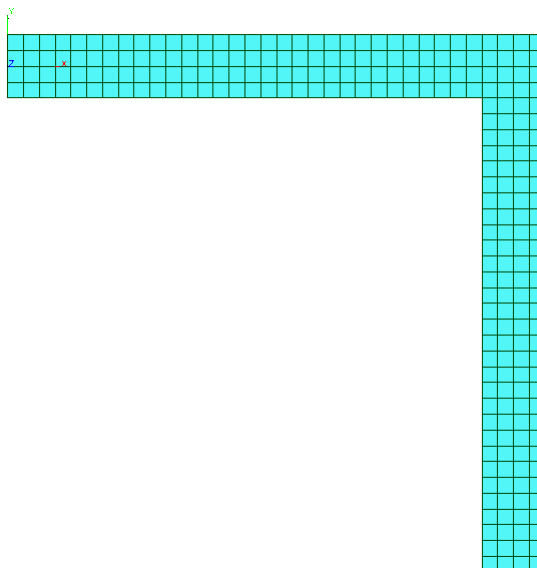
| *The results of this modeling differ slightly from the others probably because of warping.*



## 8 Modeling F

### 8.1 Characteristics of modeling

Modeling COQUE\_3D



### 8.2 Characteristics of the grid

Many nodes: 1161

Many meshes and types: 256 QUAD9

### 8.3 Sizes tested and results

Loading case	Reference	Tolerance (%)
1	1,088	15.0
2	0,680	1.2

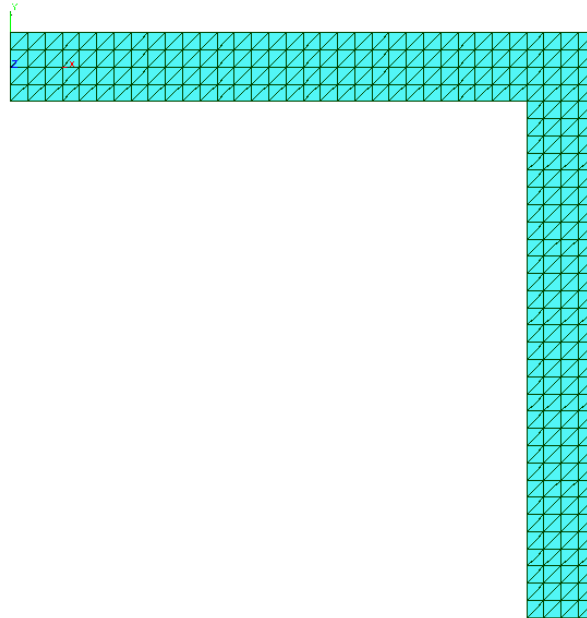
**Note:**

| this modeling tests the criterion of buckling in the nonlinear operator of statics.

## 9 Modeling G

### 9.1 Characteristics of modeling

Modeling COQUE\_3D



### 9.2 Characteristics of the grid

Many nodes: 1161  
Many meshes and types: 512 TRIA7

### 9.3 Sizes tested and results

Loading case	Reference	Tolerance (%)
1	1,088	15.5
2	0,680	0.9

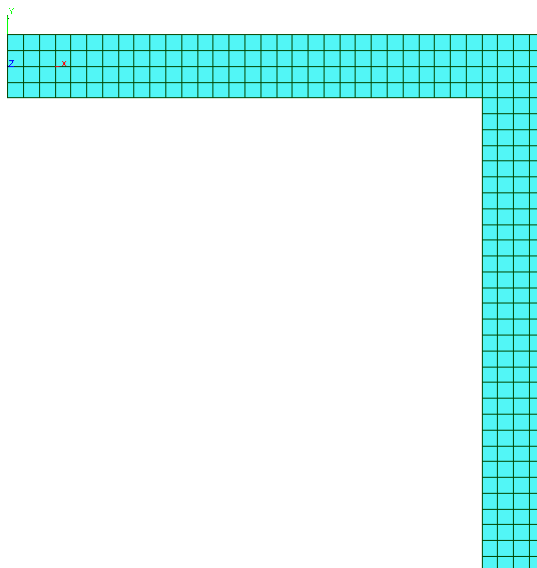
**Note:**

| *this modeling tests the criterion of buckling in the nonlinear operator of statics.*

## 10 Modeling H

### 10.1 Characteristics of modeling

Modeling DKT



### 10.2 Characteristics of the grid

Many nodes: 325

Many meshes and types: 325 QUAD4

### 10.3 Sizes tested and results

Loading case	Reference	Tolerance (%)
1	1,088	15.0
2	0,680	1.0

**Note:**

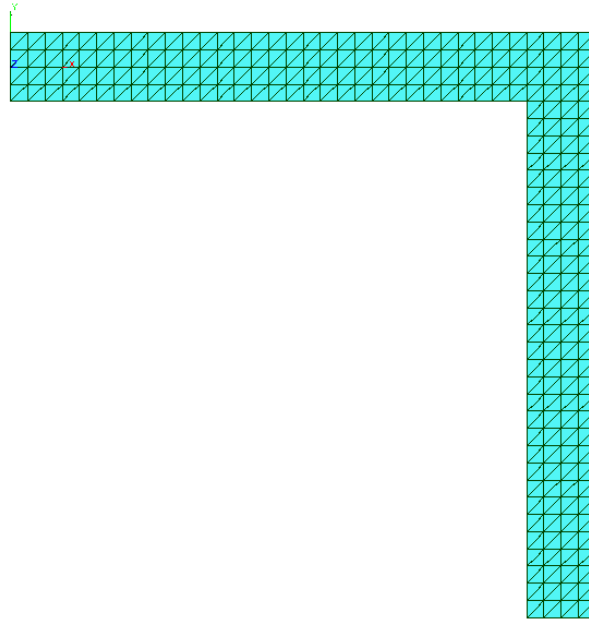
| this modeling tests the criterion of buckling in the nonlinear operator of statics.

## 11 Modeling I

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### 11.1 Characteristics of modeling

Modeling DKT



### 11.2 Characteristics of the grid

Many nodes: 1161  
Many meshes and types: 512 TRIA3

### 11.3 Sizes tested and results

Loading case	Reference	Tolerance (%)
1	1,088	15.5
2	0,680	0.8

**Note:**

| *this modeling tests the criterion of buckling in the nonlinear operator of statics.*

## 12 Summary of the results

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### Modelings beam:

The results of 5 modelings beams are very close to the reference solution which is an average of results of 8 codes. One notes a small effect due to warping since results of modelings C and E (POU\_D\_TG/POU\_D\_TGM) are slightly different from the others, while remaining with less 2% reference.

Although two last modelings (D and E) implement the nonlinear criterion of buckling of CRIT\_STAB in the nonlinear operator of statics, they do not use the same approach.

In modeling D, it is the criterion of Euler who is used because one is in small displacements (DEFORMATION=' PETIT ') and the tangent matrix contains only the matrix of material rigidity.

In modeling E, one placed oneself in great displacements (DEFORMATION=' REAC\_GEOM ', although that is not necessary to deal with this problem), the tangent matrix understands at the same time rigidities material and geometrical, which makes it possible to illustrate the nonlinear criterion generalized in which one tests the singularity of the tangent matrix. One thus does not predict any more the critical load but it is detected (by observing the change of sign of the smallest eigenvalue of the tangent matrix, confer [R7.05.01]).

### Modelings hull:

In these modelings, it is the criterion of Euler who is used because one is in small displacements (DEFORMATION=' PETIT ') and the tangent matrix contains only the matrix of material rigidity.

Results of modelings DKT (QUAD4, TRIA3) and COQUE\_3D (QUAD9, TRIA7) are far away from the reference solution, with a maximum change of 15.5% for the first mode of buckling. On the other hand the results are satisfactory for the second mode, with a variation of 1.2%