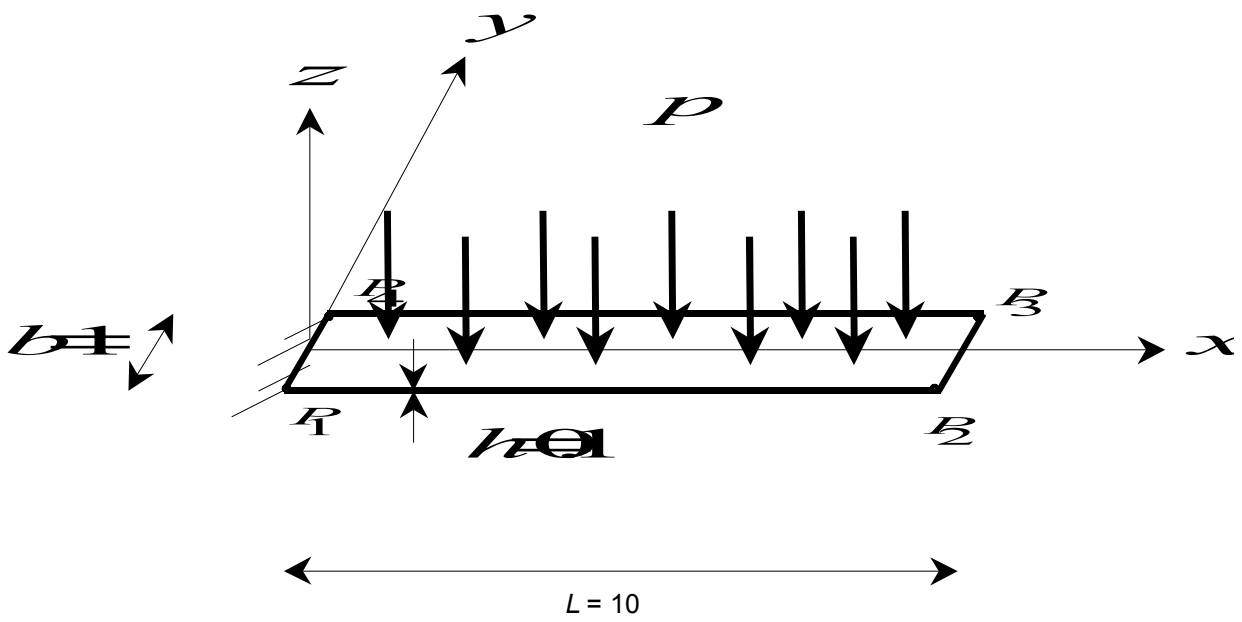
SSNV145 - Plate cantilever in great rotations subjected to a following pressure

Summary

One presents a quasi-static calculation of elastic plate embedded on a side and subjected to a following pressure. The following loading implies modifications of the system of equations linearized. The system of equations solved by the method of NEWTON is nonsymmetrical. The tangent matrix of rigidity (interior forces) and the contribution of the compressive forces according to the deformation of the structure are nonsymmetrical. This modeling makes it possible to test the geometrical nonlinear finite elements objects COQUE_3D using the algorithm of update of great rotations 3D GROT_GDEP in STAT_NON_LINE in the presence of pressure of a following type. The reference solution is obtained by the software finite elements the SAMCEF software.

1 Problem of reference

1.1 Geometry



The lengths are given in meters.
Rectangular plate thickness $0.1\mathrm{m}$ embedded in $P_1 P_4$ and subjected to a pressure:

$$\mathbf{p} = - p \quad \mathbf{e}_z \quad p > 0$$

1.2 Properties of materials and characteristic of section

Elastic behavior:

$$E = 12 \times 10^6 \ Pa \quad ; \quad \nu = 0.3$$

1.3 Boundary conditions and loading

Embedding in $P_1 P_4$. One seeks the successive states of balance under the loading made up of the pressure:

$$p = t \quad ; \quad t \text{ pseudo-time.}$$

One is interested particularly in displacements horizontal and vertical and rotation in the center of the line $P_2 P_3$.

2 Reference solution

2.1 Method of calculating used to obtain the reference solution

The reference solution [bib4] is that which is obtained with software the SAMCEF software [bib1]. Modeling is based on a theory of hull in resulting efforts with a rotational formulation Co - [bib3] and a discretization DSQ [bib2] regular.

The grid considered is a regular grid of 20×1 quadrilateral elements with 4 nodes each one.

2.2 Results of reference

One tests the pseudo-temporal evolution of DX, DZ, DRY at the point medium of the segment $P1P2$.

2.3 Bibliographical references

1) The SAMCEF software, Handbook of reference V7.1 Elements Volume, 1998

2) J-L. Batoz, G.Dhatt, “Modeling of the Structures by Finite elements: Beams and Plates”, Hermes, Paris, 1992

3) Crisfield M.A., “Non-linear Finite Element Analysis of Solids and Structures”, Volume 1: Essentials, John Wiley, Chichester, 1994

4) PH. JETTEUR, Kinematic Non Linéaire of the Hulls. Report SAMTECH, Contract PP/GC-134/96, 1998

5) Mr. AL MIKDAD, following Pressure for the elements COQUE_3D, N° Report 99020-1 1999

3 Modeling A

3.1 Characteristics of modeling

MEC3QU9H (hull 3D degenerated)

modeling COQUE_3D - regular grid.

3.2 Characteristics of the grid

Many nodes: 33

Number of meshs and type: 10 QUAD9

3.3 Features tested

- The geometrical nonlinear element COQUE_3D,
- The static algorithm of update of great rotations GROT_GDEP of STAT_NON_LINE,
- The use of a following pressure.

3.4 Results of modeling A

History of horizontal displacement DX (m) in the middle of $P1P2$

Moment	Pressure p	Reference (The SAMCEF software)
13.	13.	– 9.03743E+00
26.	26.	– 1.41513E+01

History of vertical displacement DZ (m) in the middle of $P1P2$

Moment	Pressure P	Reference (The SAMCEF software)
13.	13.	– 8.42753E+00
26.	26.	– 4.43375E+00

History of horizontal rotation DRY in the middle of $P1P2$

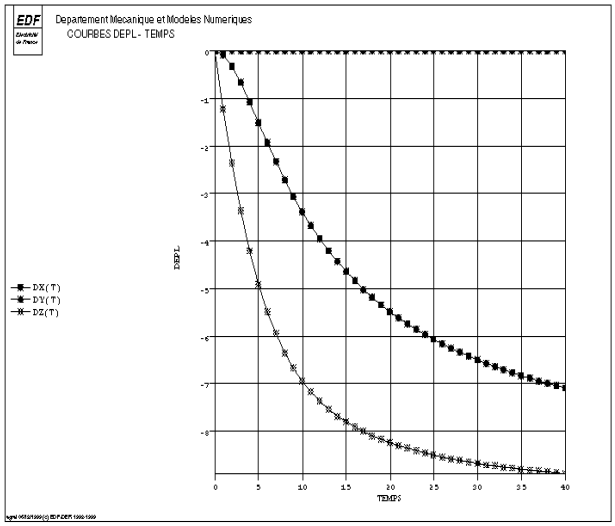
Moment	Pressure p	Reference (The SAMCEF software)
13.	13.	1.94328E+00
26.	26.	3.09814E+00

3.5 Remarks

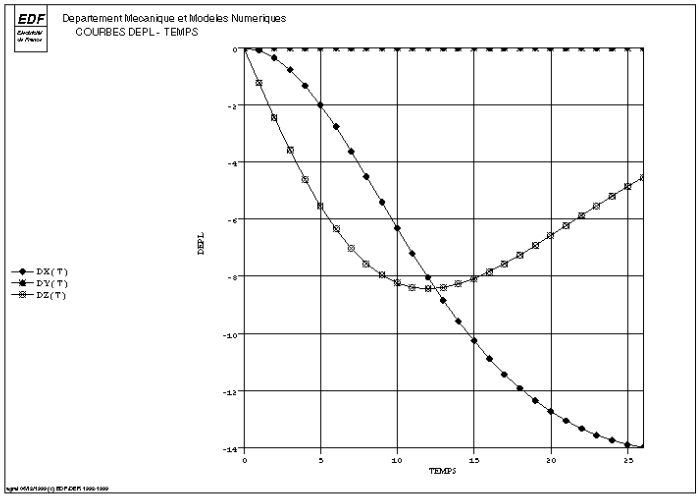
The number of meshs of the reference solution is 2 times larger than that of the solution of modeling A.

One uses the value of COEF_RIGI_DRZ = 0,001.

The following figures, illustrate the solution obtained with a nonfollowing and following pressure. They acts of the components of translation of the medium of the loose lead.



Nonfollowing pressure



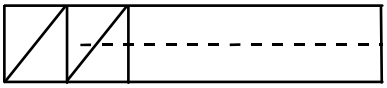
Following pressure

It is seen that in the case of a following pressure, displacement DZ decrease after having reached a maximum. The beam tends to be rolled up. This phenomenon is not representable with nonfollowing pressures.

4 Modeling B

4.1 Characteristics of modeling

MEC3TR7H (hull 3D degenerated)



1 *élément*

20 *éléments - 10 subdivisions*

modeling COQUE_3D - regular but nonsymmetrical grid.

The facts of the case correspond to a thin hull $\frac{h}{L}=0.625\%$ what is severe for the finite element MECQTR7H (case of blocking to transverse shearing).

4.2 Characteristics of the grid

Many nodes: 33

Number of meshs and type: 20 TRIA7

4.3 Features tested

- The geometrical nonlinear element COQUE_3D,
- The static algorithm of update of great rotations GROT_GDEP of STAT_NON_LINE,
- The use of a following pressure.

4.4 Results of modeling B

History of horizontal displacement DX (m) in the middle of $P1P2$

Moment	Pressure p	Reference (The SAMCEF software)
11.	11.	-7.36640 E+00
22.	22.	-1.35098 E+01

History of vertical displacement DZ (m) in the middle of $P1P2$

Moment	Pressure P	Reference (The SAMCEF software)
11.	11.	-8.44920 E+00
22.	22.	-5.78828 E+00

History of horizontal rotation DRY in the middle of $P1P2$

Moment	Pressure p	Reference (The SAMCEF software)
11.	11.	1.69200 E+00
22.	22.	2.82168 E+00

4.5 Remarks

The grid of modeling B is a regular but nonsymmetrical grid. The grid of the reference solution is built with 20 quadrangles with 4 nodes each one.

One uses the value of COEF_RIGI_DRZ = 0,001.

Although the studied problem is a mean problem of hull $\frac{h}{L}=0.625\%$, the elements of triangles reach a high level of load: 22 pas for 26 with the quadrangles. The solution with elements triangle is thus very satisfactory.

5 Summary of the results

Solutions obtained by *Code_Aster* are very close to the reference solution of software the SAMCEF software, with a grid twice less refined. The values of displacement at the end of the beam differ from to the more 2.5% for the first modeling in quadrangle and of to the more 6.7% for the second modeling in triangle.