

## SSNV145 - Plate cantilever in large rotations subjected to a following pressure

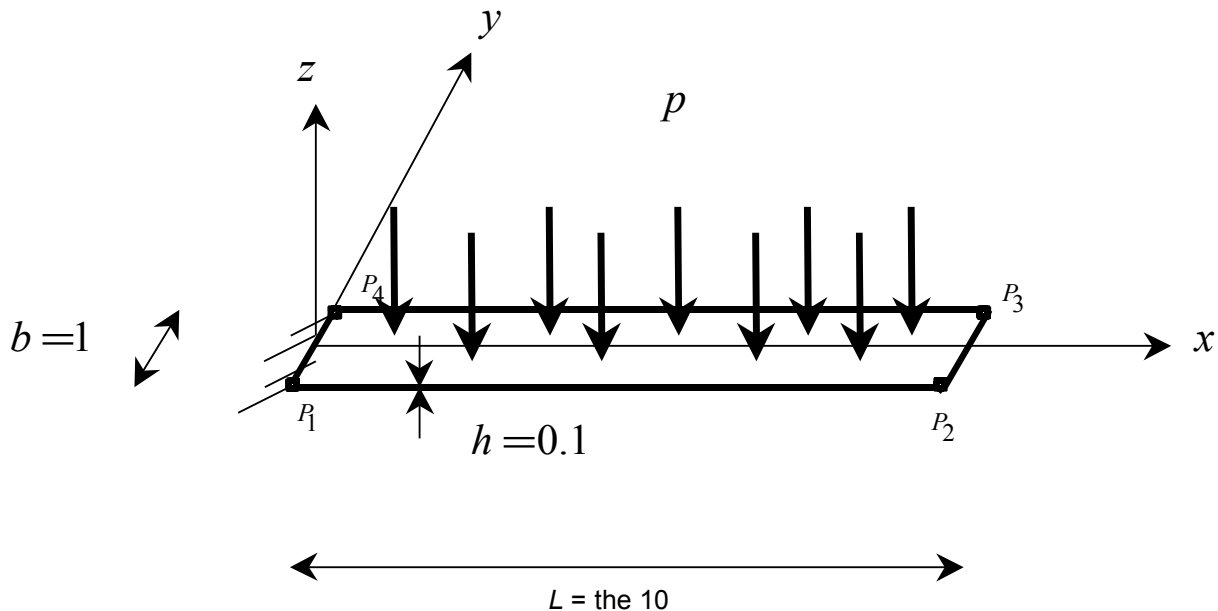
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### Abstract

One presents a quasi-static computation of elastic plate embedded on a side and subjected to a following pressure. The following loading implies modifications of the linearized system of equations. The system of equations solved by the method of `NEWTON` is asymmetric. The tangent matrix of stiffness (internal forces) and the contribution of the compressive forces according to the deformed shape of structure are asymmetric. This modelization makes it possible to test the nonlinear objects finite elements geometrical `COQUE_3D` 3D using the algorithm of update of large rotations `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



lengths are given in meters.

Rectangular plate of thickness 0.1m embedded in  $P_1 P_4$  and subjected to a pressure:

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

### 1.2 Material properties and characteristic of section

Behavior elastic:

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

### 1.3 Boundary conditions and loading

Fixed support in  $P_1 P_4$ . One seeks the successive states of equilibrium under the loading made up of the pressure:

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

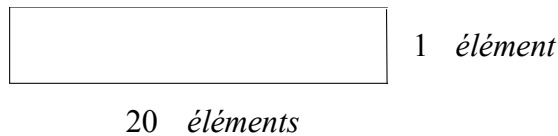
One is interested particularly in displacements horizontal and vertical and rotation in the center of line  $P_2 P_3$ .

## 2 Reference solution

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### 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]. The modelization is based on a theory of shell in resulting forces with a rotational formulation Co - [bib3] and a discretization  $DSQ$  [bib2] regular.



The mesh considered of quadrilateral elements with 4 nodes  $20 \times 1$  each one is a regular mesh.

### 2.2 Results of reference

One tests the pseudo-temporal evolution of  $DX$   $DZ$ ,  $DRY$  at the point medium of the segment  $PIP2$ .

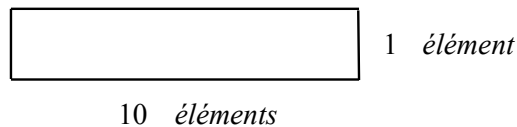
### 2.3 Bibliographical references

- 1) the SAMCEF software, Handbook of reference V7.1 Elements Volume, 1998
- 2) J-L. Batoz, G.Dhatt, "Modelization of 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, Nonlinear Kinematics of the Shells. Ratio SAMTECH, Contract PP/GC-134/96, 1998
- 5) Mr. AL MIKDAD, following Pressure for the elements COQUE\_3D, N° Ratio 99020-1 1999

### 3 Modelization A

#### 3.1 Characteristic of modelization

MEC3QU9H (shell 3D degenerated)



modelization COQUE\_3D - regular mesh.

#### 3.2 Characteristics of the mesh

Many nodes: 33

Number of meshes and type: 10 QUAD9

#### 3.3 Functionalities tested

nonlinear element geometrical COQUE\_3D,  
the static algorithm of update of large rotations GROT\_GDEP of STAT\_NON\_LINE,  
the use of a following pressure.

#### 3.4 Results of the modelization A

History of horizontal displacement  $DX$  ( m ) in the middle of  $PIP2$

Time	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  $PIP2$

Time	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  $PIP2$

Time	Pressure $p$	Reference (the SAMCEF software)
13.	13.	1.94328E+00
26.	26.	3.09814E+00

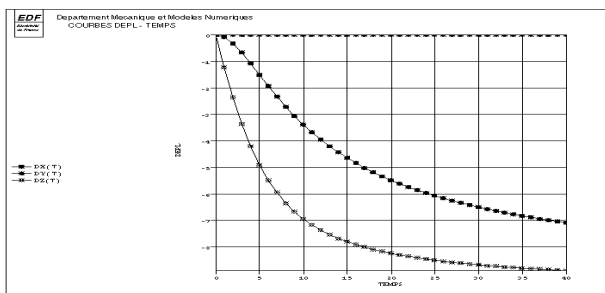
#### 3.5 Remarks

the number of meshes of the reference solution is 2 times larger than that of the solution of modelization A.

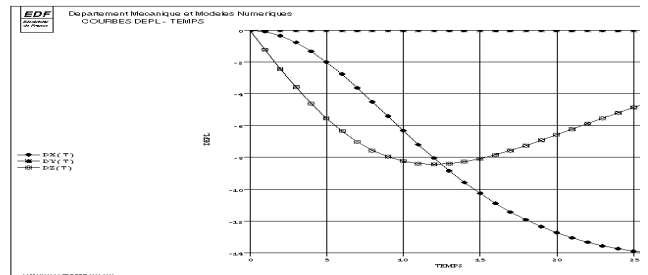
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One uses the value of  $\text{COEF\_RIGI\_DRZ} = 0.001$ .

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.



Pressure nonfollowing



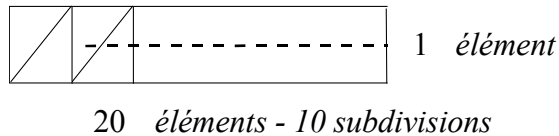
Pressure following

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

## 4 Modelization B

### 4.1 Characteristic of modelization

MEC3TR7H (shell 3D degenerated)



modelization COQUE\_3D - regular but asymmetric mesh.

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

### 4.2 Characteristics of the mesh

Many nodes: 33

Number of meshes and type: 20 TRIA7

### 4.3 Functionalities tested

nonlinear element geometrical COQUE\_3D,  
the static algorithm of update of large rotations GROT\_GDEP of STAT\_NON\_LINE,  
the use of a following pressure.

### 4.4 Results of the modelization B

History of horizontal displacement  $DX$  ( m ) in the middle of  $PIP2$

Time	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  $PIP2$

Time	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  $PIP2$

Time	Pressure $p$	Reference (the SAMCEF software)
11.	11.	1.69200 E+00
22.	22.	2.82168 E+00

## 4.5 Remarks

The mesh of the modelization B is a regular but asymmetric mesh. The mesh 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 shell  $\frac{h}{L} = 0.625\%$ , the triangular elements reach a high level of load: 22 step for 26 with the quadrangles. The solution with elements triangle is thus very satisfactory.

## 5 Summary of the results

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the solutions obtained by *Code\_Aster* are very close to the reference solution of software the SAMCEF software, with a mesh twice less refined. The values of displacement at the end of the beam differ from to the more 2,5% for the first modelization in quadrangle and of to the more 6,7% for the second modelization in triangle.