SSNV129 - Contact of 2 simple bearing plates of which is subjected to pressure

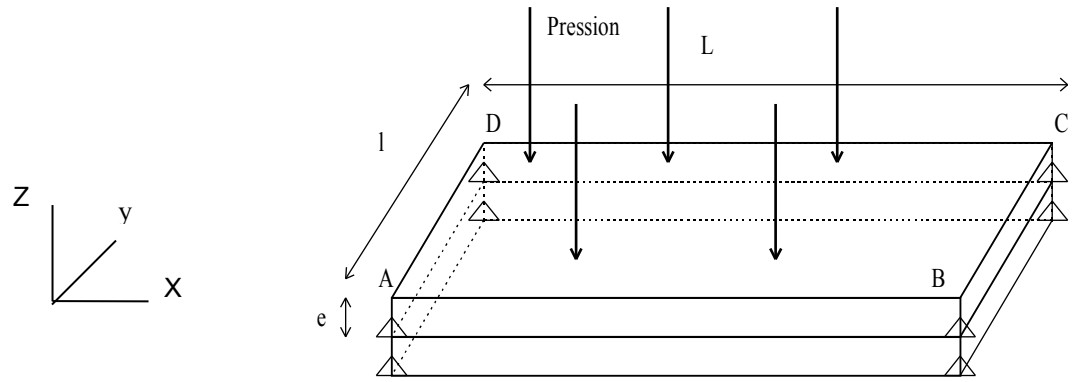
Summarized:

A rectangular plate is subjected to a uniform compressive force and is compressed on an identical plate where it undergoes forces of contact.

This test comprises two modelizations (linear elements QUAD4 with modelization DKT - elements quadratic QUAD9 with modelization COQUE_3D). Computations of reference were carried out without contact.
The results of *Code_Aster* with contact are got into non regression and are analyzed compared to the results got without contact.

1 Problem of reference

1.1 Geometry



Thickness of the plate: $e=0,5\ cm$.
Width of the plate : $l=5\ cm$.
Length of the plate: $L=10\ cm$.

Coordinates of the points of reference (cm)

	x	y	z
A	0	– 2.5	0
B	10	– 2.5	0
C	10.2.5		0
D	0.2.5		0

1.2 Material properties

Plates:

Poisson's ratio: 0.3
Young modulus: $2.10^{15}\ N/m^2$

1.3 Boundary conditions and loadings

the plate is blocked:

on AB and CD for displacements according to y and z ,
on BC and DA for displacements according to x and z ,
on AB and CD for rotations according to y ,
on AD and BC for rotations according to x .

One also blocks the central node of each plate to leave him the only possibility of moving along the axis z .

The plate is subjected to a vertical pressure distributed on the higher plate:

Pressure: $p=2.510^{12}\ N/m^2$,

2 Reference solution

2.1 Bibliographical reference

the reference solution comes from the results got in “S Formulated for Stress and Strain” of ROARK' (6th edition - McGraw-Hill International Editions), which one can also find in the memorandum on the strength of materials of Jean Narrow part and Jean-Pierre Boutin, page 192, combined with “Formulated for Stress, Structural Strains and Matrixes” of W.D. Pilkey, page 969.

2.2 Analytical results of reference without contact

the got results were calculated on a simple bearing plate subjected to a vertical pressure (not of contact).

Computation of the deflection in the center of the plate:

$$max\ z = -\frac{\alpha\, p\, l^4}{E\, e^3}$$

Computation of the stress in the center of the plate according to the width of the plate in lower skin:

$$\sigma_{yy} = \frac{+\beta\ \mathrm{pl}^2}{\mathrm{e}^2} \quad \sigma_{yy} = +\frac{\beta\, p\, l^2}{e^2}$$

p indicate the pressure applied to the plate,
E the modulus Young
L , the length
l , the width
e , the thickness,
α , β being two coefficients obtained starting from the ratio a/b .

$$\begin{cases} \alpha = 0.1110 \\ \beta = 0.6102 \end{cases}$$

That is to say:

$$\begin{cases} max\ z = -0.69375\, cm \\ \sigma_{yy} = 1.5255\, 10^{10}\, N/cm^2 \end{cases}$$

2.3 Results got without contact with *Code_Aster*

2.3.1 Modelization DKT

Modelization: DKT to test the contact between two plates.

256 finite elements QUAD4 are laid out on initial contact surface. The mesh only one layer of elements in the thickness of the plate has.

2.3.2 Characteristics of the mesh

Many nodes: 289 nodes
Number of meshes and standard: 256 QUAD4

2.3.3 Values of reference Aster

Identification	Reference	*Aster* (DKT)	Error
DZ to the center of the plate	- 0.69375	- 0.69138	0.35%
σ_{yy} to the center of the plate	+ 1.5255 E+10	+ 1.5298 E+10	0.28%

2.3.4 Modelization COQUE_3D

Modelization: COQUE_3D to test the contact between two plates.

256 finite elements QUAD9 are laid out on initial contact surface. The mesh only one layer of elements in the thickness of the plate has.

2.3.5 Characteristics of the mesh

Many nodes: 578 nodes
Number of meshes and standard: 256 QUAD9

2.3.6 Values of reference Aster

Identification	Reference	*Aster* (COQUE_3D)	Error
DZ to the center of the plate	- 0.69375	- 0.65927	4.97%
σ_{yy} to the center of the plate	+ 1.5255 E+10	+ 1.41316 E+10	7.36%

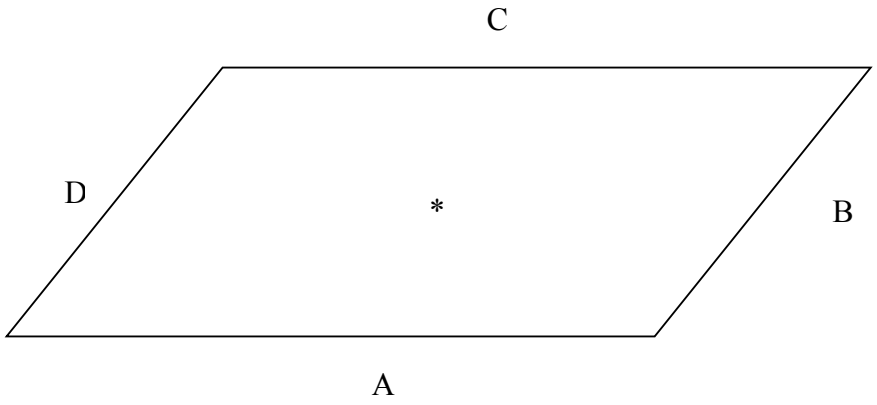
2.4 Comments

One note that the results got without contact are very satisfactory for a modelization of the type DKT. The error obtained for a modelization of the type COQUE_3D can be explained by the taking into account of the effects of transverse shears which should not be negligible for this relatively thick plate since the ratio l/e is worth $1/10$.

3 Modelization A

3.1 Characteristic of the modelization

Modelization: DKT to test the contact between two plates.



where * the medium node of the plate indicates.
$A = DR1$ or $DR21$,
$B = DR2$ or $DR22$,
$C = DR3$ or $DR23$,
$D = DR4$ or $DR24$.

The nodes to which one applies the boundary conditions are the named nodes centre1 and centre2 located at the center of each plate.

The computation by the method of the active stresses is carried out without geometrical reactualization and on only one time step.

3.2 Characteristics of the mesh

Use of meshes QUAD4

3.3 Values tested

Identification of the Analytical central	*node*
DZ	-3.426875 E-01
σ_{yy}	+7.6481 E+09

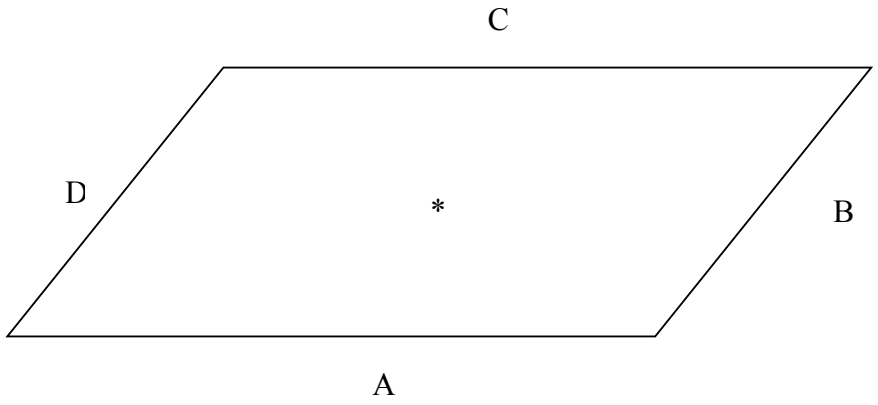
3.4 Comments

the results got with contact are very satisfactory since one obtains, with less than 1% of error, the results got without contact except for a factor of 2. It result is indeed expected since to add the contact between two plates identical to that of paragraph 2 amounts supposing a plate subjected to pressure with a stiffness twice higher.

4 Modelization B

4.1 Characteristic of the modelization

Modelization: COQUE_3D to test the contact between two plates.



where * the medium node of the plate indicates.
$A = DR1$ or $DR21$,
$B = DR2$ or $DR22$,
$C = DR3$ or $DR23$,
$D = DR4$ or $DR24$.

The nodes to which one applies the boundary conditions are the nodes named $cente1$ and $cente2$ located at the center of each plate.

4.2 Characteristics of the mesh

Use of meshes QUAD9

4.3 Values tested

Identification of the Analytical central	*node*
DZ	-3.426875 E-01
σ_{yy}	+7.6481 E+09

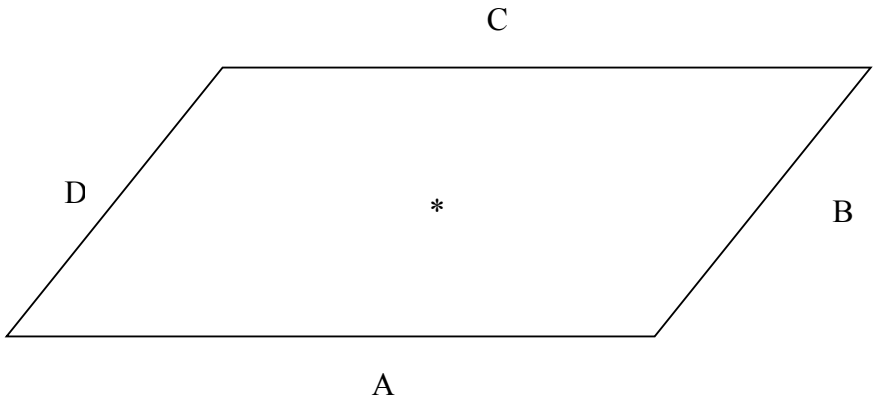
4.4 Comments

the results got with contact are acceptable since one obtains an error of the same order of magnitude as those without contact with only one plate 2 times thicker.

5 Modelization C

5.1 Characteristic of the modelization

Modelization: COQUE_3D to test the contact between two plates.



where * the medium node of the plate indicates.
$A = DR1$ or $DR21$,
$B = DR2$ or $DR22$,
$C = DR3$ or $DR23$,
$D = DR4$ or $DR24$.

The nodes to which one applies the boundary conditions are the named nodes cente1 and cente2 located at the center of each plate.

The computation by the method of the active stresses is carried out without geometrical reactualization and on only one time step.

5.2 Characteristics of the mesh

Use of meshes TRIA6

5.3 Values tested

Identification of the Analytical central	*node*
DZ	-3.426875 E-01
σ_{yy}	7.6481 E+09

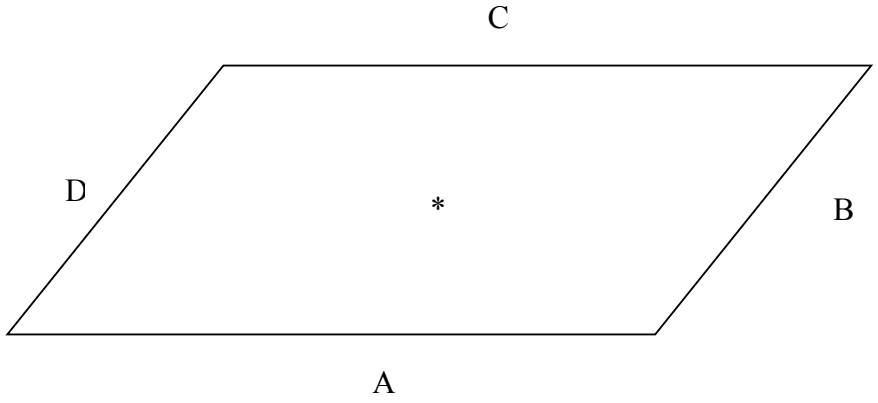
5.4 Comments

the results got with contact are acceptable since one obtains an error of the same order of magnitude as those without contact with only one plate 2 times thicker.

6 Modelization D

6.1 Characteristic of the modelization

Modelization: DKT to test the contact between two plates.



where * the medium node of the plate indicates.
$A = DR1$ or $DR21$,
$B = DR2$ or $DR22$,
$C = DR3$ or $DR23$,
$D = DR4$ or $DR24$.

The nodes to which one applies the boundary conditions are the named nodes cente1 and cente2 located at the center of each plate.

The computation by the method of the active stresses is carried out without geometrical reactualization and on only one time step.

6.2 Characteristics of the mesh

Use of meshes QUAD4

6.3 Values tested

Identification of the Analytical central	*node*
DZ	-3.426875 E-01
σ_{yy}	7.6481 E+09

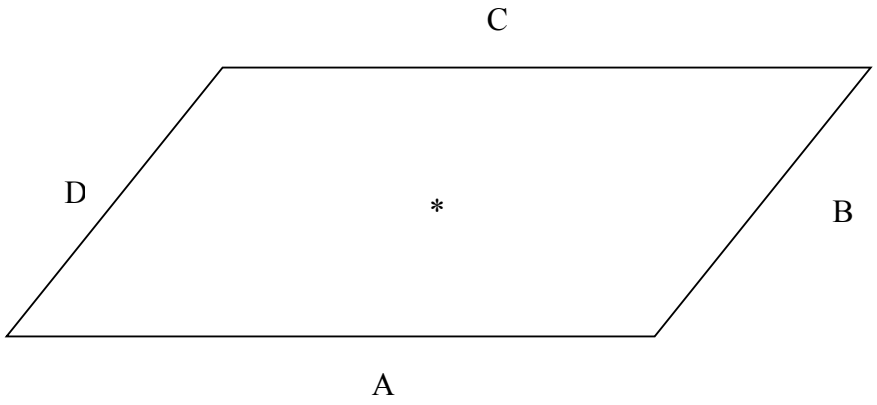
6.4 Comments

the results got with contact are very satisfactory since one obtains, with less than 1% of error, the results got without contact except for a factor of 2. It result is indeed expected since to add the contact between two plates identical to that of paragraph 2 amounts supposing a plate subjected to pressure with a stiffness twice higher.

7 Modelization E

7.1 Characteristic of the modelization

Modelization: DKT to test the contact between two plates.



where * the medium node of the plate indicates.
$A = DR1$ or $DR21$,
$B = DR2$ or $DR22$,
$C = DR3$ or $DR23$,
$D = DR4$ or $DR24$.

The nodes to which one applies the boundary conditions are the named nodes cente1 and cente2 located at the center of each plate.

The computation by the method of the active stresses is carried out without geometrical reactualization and on only one time step.

7.2 Characteristics of the mesh

Use of meshes QUAD4

7.3 Values tested

Identification of the Analytical central	*node*
DZ	-3.426875 E-01
σ_{yy}	7.6481 E+09

7.4 Comments

the results got with contact are very satisfactory since one obtains, with less than 1% of error, the results got without contact except for a factor of 2. It result is indeed expected since to add the contact between two plates identical to that of paragraph 2 amounts supposing a plate subjected to pressure with a stiffness twice higher.

9 Summary of the results

One notes very good performances in the presence of contact for the two modelizations.

The modelizations A, D and E (DKT) have very satisfactory results compared to the analytical results (– 1% of error with or without contact). When one replaces a plate under pressure by two plates from which one comes to be stuck to the other, the multiplication of the stiffness by two results in a division by two of the maximum deflection as well as stress in the center of the plates.

The modelization B, C (COQUE_3D) give a behavior equivalent to that met for the modelizations A, D and E in DKT when one replaces a plate under pressure by two plates in contact. One observes a division by two of the maximum deflection as well as stress in the center of the plates. Moreover, the value of the deflection obtained is rather satisfactory (~7% of error) compared to the analytical results. This difference can be explained by the taking into account of the transverse shears for the COQUE_3D for a plate which is altogether relatively thick since $l/e=1/10$.