

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

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### Summary:

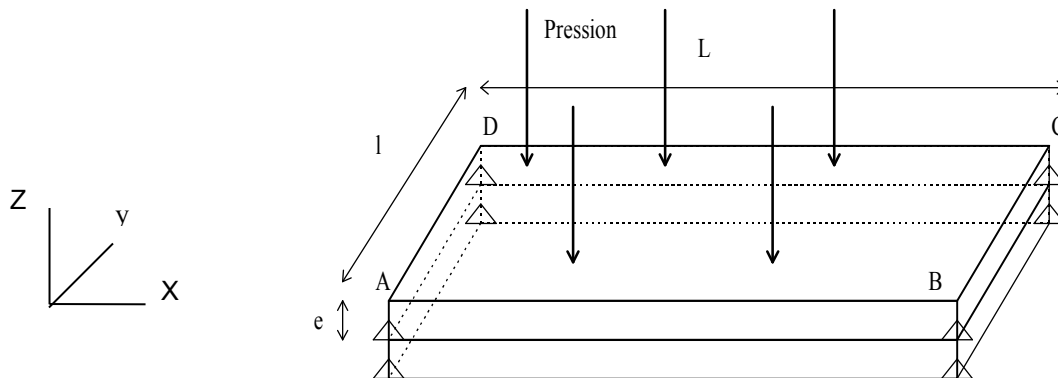
A rectangular plate is subjected to a uniform compressive force and is compressed on an identical plate where it undergoes forces of contact.

This test comprises two modelings (linear elements QUAD4 with modeling DKT - quadratic elements QUAD9 with modeling COQUE\_3D). Calculations of reference were carried out without contact.

Results of *Code\_Aster* with contact are obtained in nonregression and are analyzed compared to the results got without contact.

## 1 Problem of reference

### 1.1 Geometry



Thickness of the plate:  $e = 0,5 \text{ cm}$  .

Width of the plate :  $l = 5 \text{ cm}$  .

Length of the plate:  $L = 10 \text{ cm}$  .

Coordinates of the points of reference (  $\text{cm}$  )

	$x$	$y$	$z$
$A$	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:  $2 \cdot 10^{15} \text{ N/m}^2$

### 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:  $p = 2.5 \cdot 10^{12} \text{ N/m}^2$  ,

## 2 Reference solution

### 2.1 Bibliographical reference

The reference solution comes from the results got in "Formulated for Stress and Strain" of ROARK' S (6<sup>ème</sup> edition - McGraw-Hill International Editions), that one can also find in the memorandum on the resistance of materials of Jean Goulet and Jean-Pierre Boutin, page 192, combined with "Formulated for Stress, Structural Strains and Matrices" 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).

- Calculation of the arrow in the center of the plate:

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

- Calculation of the constraint in the center of the plate according to the width of the plate in lower skin:

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

- $p$  indicate the pressure applied to the plate,
- $E$  the Young modulus,
- $L$ , the length,
- $l$ , the width,
- $e$ , the thickness,
- $\alpha, \beta$  being two coefficients obtained starting from the report  $a/b$ .

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

That is to say:

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

## 2.3 Results got without contact with Code\_Aster

### 2.3.1 Modeling DKT

Modeling: `DKT` to test the contact between two plates.

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

### 2.3.2 Characteristics of the grid

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

### 2.3.3 Values of reference Aster

Identification	Reference	Aster (DKT )	Error
$DZ$ in the center of the plate	- 0.69375	- 0.69138	0.35%
$\sigma_{yy}$ in the center of the plate	+ 1.5255 E+10	+ 1.5298 E+10	0.28%

### 2.3.4 Modeling COQUE\_3D

Modeling: `COQUE_3D` to test the contact between two plates.

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

### 2.3.5 Characteristics of the grid

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

### 2.3.6 Values of reference Aster

Identification	Reference	Aster (COQUE_3D)	Error
$DZ$ in the center of the plate	- 0.69375	- 0.65927	4.97%
$\sigma_{yy}$ in the center of the plate	+ 1.5255 E+10	+ 1.41316 E+10	7.36%

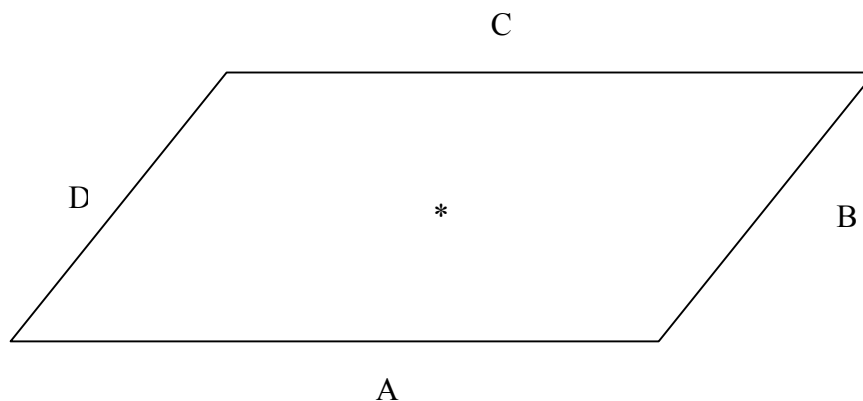
## 2.4 Comments

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

## 3 Modeling A

### 3.1 Characteristics of modeling

Modeling: DKT to test the contact between two plates.



where \* indicate the node medium of the plate.

$A = DR1$  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.

Calculation by the method of the active constraints is carried out without geometrical reactualization and on only one step of time.

### 3.2 Characteristics of the grid

Use of meshes QUAD4

### 3.3 Values tested

Identification of the central node	Analytical
$DZ$	-3.426875 E-01
$\sigma_{yy}$	+7.6481 E+09

### 3.4 Comments

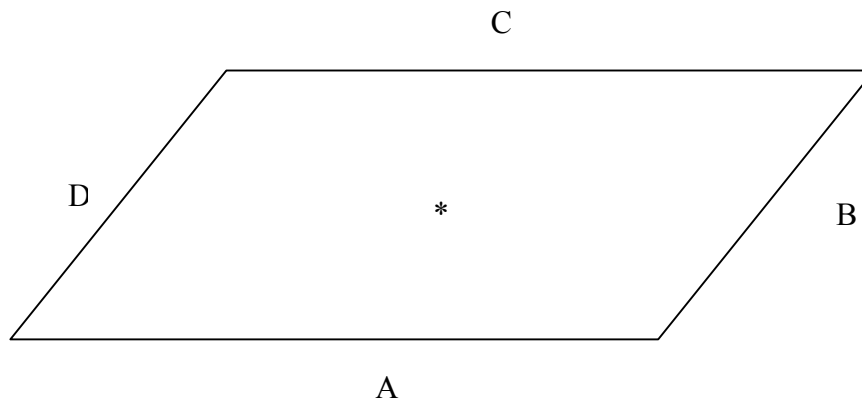
The results got with contact are very satisfactory since one obtains, with less than 1% of error, the results got without contact except for a factor of 2. It is indeed the expected result since to add the contact between two plates identical to that of paragraph 2 amounts supposing a plate subjected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

## 4 Modeling B

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### 4.1 Characteristics of modeling

Modeling: COQUE\_3D to test the contact between two plates.



where \* indicate the node medium of the plate.

$A = DR1$  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.

### 4.2 Characteristics of the grid

Use of meshes QUAD9

### 4.3 Values tested

Identification of the central node	Analytical
$DZ$	-3.426875 E-01
$\sigma_{yy}$	+7.6481 E+09

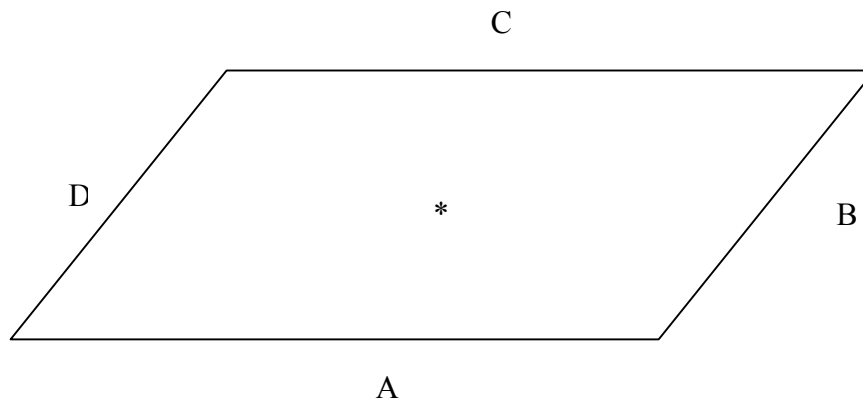
### 4.4 Comments

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 plates 2 times thicker.

## 5 Modeling C

### 5.1 Characteristics of modeling

Modeling: COQUE\_3D to test the contact between two plates.



where \* indicate the node medium of the plate.

$A = DR1$  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.

Calculation by the method of the active constraints is carried out without geometrical reactualization and on only one step of time.

### 5.2 Characteristics of the grid

Use of meshes TRIA6

### 5.3 Values tested

Identification of the central node	Analytical
$DZ$	-3.426875 E-01
$\sigma_{yy}$	7.6481 E+09

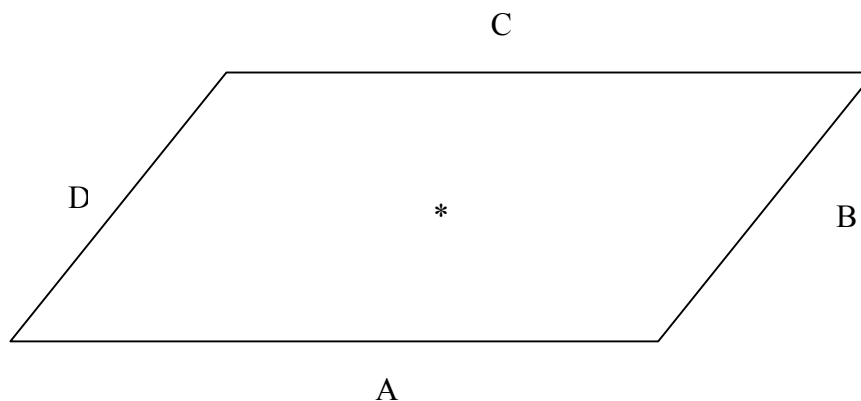
### 5.4 Comments

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 plates 2 times thicker.

## 6 Modeling D

### 6.1 Characteristics of modeling

Modeling: DKT to test the contact between two plates.



where \* indicate the node medium of the plate.

$A = DR1$  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.

Calculation by the method of the active constraints is carried out without geometrical reactualization and on only one step of time.

### 6.2 Characteristics of the grid

Use of meshes QUAD4

### 6.3 Values tested

Identification of the central node	Analytical
$DZ$	-3.426875 E-01
$\sigma_{yy}$	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 is indeed the expected result since to add the contact between two plates identical to that of paragraph 2 amounts supposing a plate subjected to pressure with a rigidity twice higher.

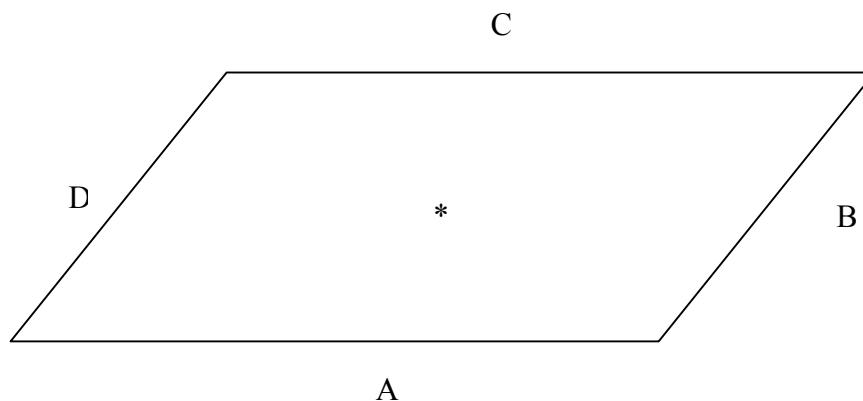


## 7 Modeling E

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### 7.1 Characteristics of modeling

Modeling: DKT to test the contact between two plates.



where \* indicate the node medium of the plate.

$A = DR1$  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.

Calculation by the method of the active constraints is carried out without geometrical reactualization and on only one step of time.

### 7.2 Characteristics of the grid

Use of meshes QUAD4

### 7.3 Values tested

Identification of the central node	Analytical
$DZ$	-3.426875 E-01
$\sigma_{yy}$	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 is indeed the expected result since to add the contact between two plates identical to that of paragraph 2 amounts supposing a plate subjected to pressure with a rigidity twice higher.

## 8 Summary of the results

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

Modelings 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 rigidity by two results in a division by two of the maximum arrow as well as constraint in the center of the plates.

Modeling B, C (COQUE\_3D) give a behavior equivalent to that met for modelings 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 arrow as well as constraint in the center of the plates. Moreover, the value of the arrow obtained is rather satisfactory (~7% of error) compared to the analytical results. This difference can be explained by the taking into account of transverse shearing for COQUE\_3D for a plate which is altogether relatively thick since  $l/e=1/10$ .