
SSNP501 - Crushing of a polyurethane ring between two indeformable plates without friction

Summary:

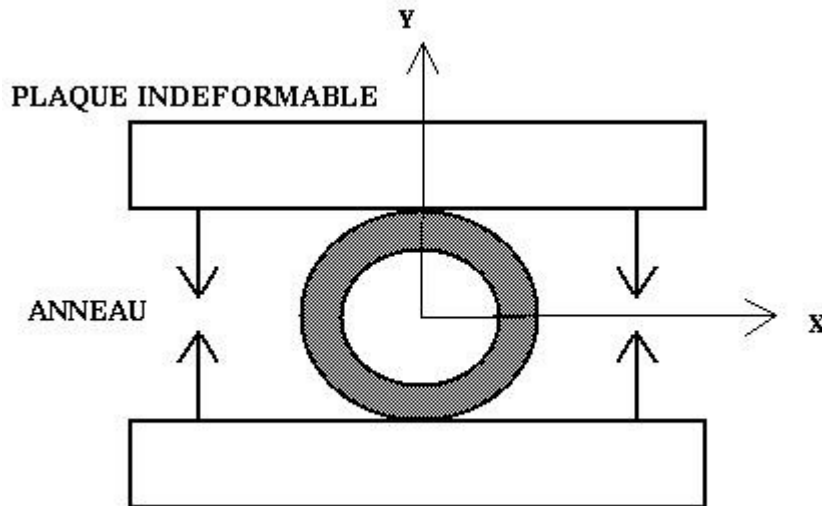
The test consists in simulating crushing in plane constraints of an elastic circular polyurethane ring by two indeformable symmetrical plates. The objective is to test the features related to the contact. This test comprises a sticking together on a zone of contact important length with the presence of great elastic strain. A symmetrical imposed displacement is applied to the two plates; the resulting force as well as the contact pressure for various points in contact are compared with the results got in the standard commodity.

In four modelings suggested, the ring is modelled with meshes QUAD4 in plane constraints:

- **modeling A**, a contact nodes - meshes (DEFI_CONTACT) **without friction** treated with the method of the active constraints was defined between the plate and the ring,
- **modeling B**, a contact nodes - meshes (DEFI_CONTACT) **without friction** treaty with the method penalized was defined between the plate and the ring,
- **modeling C**, a contact nodes - meshes (DEFI_CONTACT) **without friction** treated with the method continues was defined between the plate and the ring,
- **modeling D**, a contact nodes - meshes (DEFI_CONTACT) **without friction** treaty with the method GCP was defined between the plate and the ring.

1 Problem of reference

1.1 Geometry



ray external of the ring	6,35 cm
interior ray of the ring	4,15 cm
imposed displacement	4,45 cm

1.2 Properties of material

Ring: polyurethane, elastic law of behavior.

Young modulus:	$E = 407 \text{ N/cm}^2$
Poisson's ratio:	$\nu = 0,48$
Coefficient of friction:	$\mu = 0$

1.3 Boundary conditions and loadings

The constraints are plane.

An incremental displacement imposed of 0 with 4,45 cm is applied to the nodes of the indeformable plates.

Notice on the units:

Dimensions and displacements are in centimetres thus, to remain homogeneous, the pressures must be entered in N/cm^2 .

1.4 Initial conditions

None.

2 Reference solution

2.1 Method of calculating used for the reference solution

The solution is resulting from a computer code and an experimental test.

For the reference solution valid for a modeling of the whole plate, it is necessary to divide the normal resultant by two to obtain a reference valid for a half-plate.

2.2 Results of reference

The normal force of reaction is the following one:

Imposed displacement (<i>cm</i>)	Force of reaction (<i>N</i>)
1.1125	8.0083
2.2250	16.0166
3.3375	24.0250
4.4500	32.0333

The force of contact is bench-mark datum. It is used to define tests of validation, which are accompanied by tests of not-regression to the more severe tolerances.

2.3 Uncertainties on the solution

These results relatively approximate because are raised directly on curved paper.

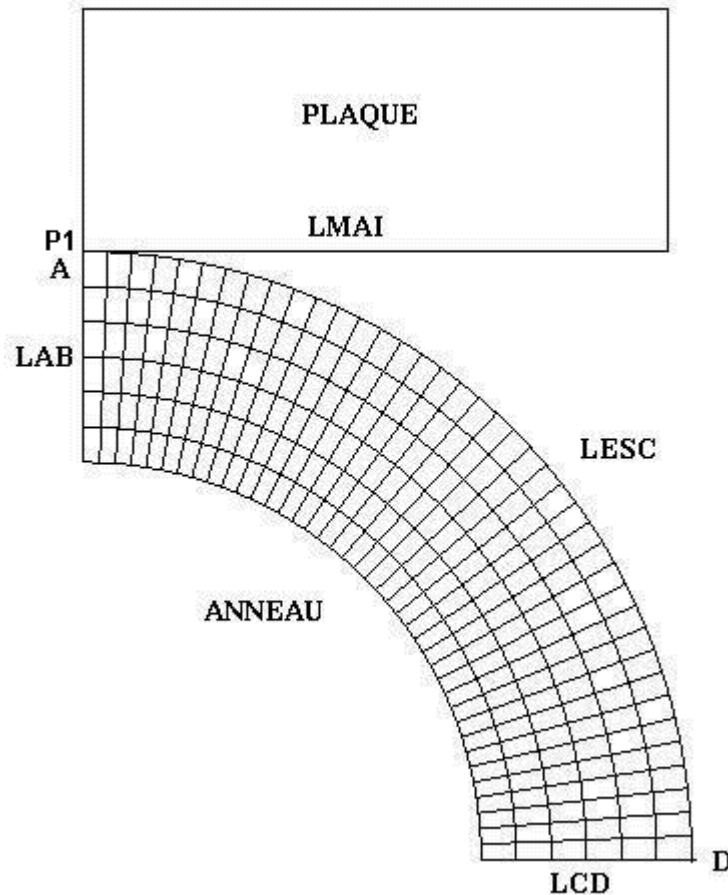
2.4 Bibliographical references

- A.F. SALEEB, K. CHEN, and T.Y.P. CHANG: "Year effective two dimensional frictional contact model for arbitrary curved geometry" - Int. J. Num. Meth. Eng. 37 (1994) p. 1297 - 1321.

3 Modeling A

3.1 Characteristics of modeling

A modeling testing the features of contact nodes - meshes (DEFI_CONTACT) without friction treated with the method of the active constraints was put in work. Taking into account the symmetry of the problem, it understands a quarter of the ring as well as the grid of an indeformable plate.



Boundary condition:

Conditions of symmetry: nodes of the group *LAB* located in the plan $X=0$ are blocked according to the direction X ($DX=0$),
nodes of the group *LCD* located in the plan $Y=0$ are blocked according to the direction Y ($DY=0$),
all nodes of the group of mesh « *Plaque* » are blocked according to the direction X ($DX=0$)

To avoid the rigid movements of body, the nodes *A* and *PI* have same vertical displacement.

Loadings:

Following imposed displacement Y on all the nodes of the plate: DY vary 0 with $2,225\text{ cm}$.
(the value of $4,45\text{ cm}$ is the vertical bringing together of the two symmetrical plates).

Note:

| The grid was carried out in cm .

3.2 Characteristics of the grid

The ring and the plate are with a grid in elements QUAD4, and it plate is rigidified because all these nodes have the same imposed displacement.

Many nodes: 290

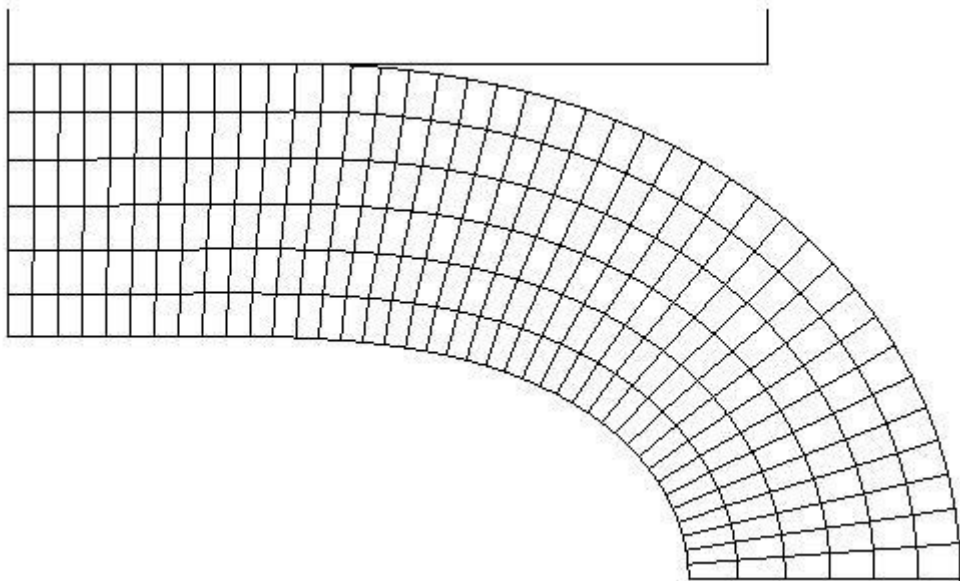
Number of meshes and type: 241 QUAD4 and 96 SEG2

3.3 Sizes tested and results

Identification	Moments	Reference	% tolerance
force of reaction (N)	1.	- 8.01	10
force of reaction (N)	2.	- 16.02	5
force of reaction (N)	3.	- 24.02	2
force of reaction (N)	4.	- 32.03	3
DX (GROUP_NO=' OF') (cm)	2.	NON_REGRESSION	
DX (GROUP_NO=' OF') (cm)	4.		
SIXX (GROUP_NO=' A') (N/cm^2)	2.		
SIXX (GROUP_NO=' A') (N/cm^2)	4.		

3.4 Remarks

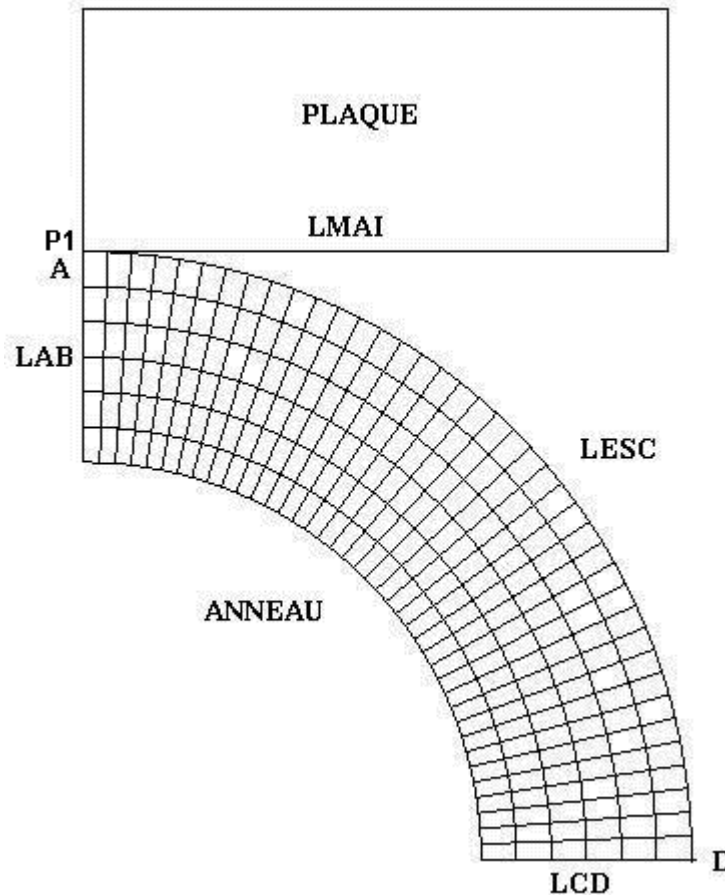
We illustrated the deformation of the ring to the step of time corresponding to a displacement of 4,45 cm :



4 Modeling B

4.1 Characteristics of modeling

A modeling testing the features of contact nodes - meshes (DEFI_CONTACT) without friction treated with the method penalized was put in work. Taking into account the symmetry of the problem, it understands a quarter of the ring as well as the grid of an indeformable plate.



Boundary condition:

Conditions of symmetry: nodes of the group *LAB* located in the plan $X=0$ are blocked according to the direction X ($DX=0$),
nodes of the group *LCD* located in the plan $Y=0$ are blocked according to the direction Y ($DY=0$),
all nodes of the group of mesh « *Plaque* » are blocked according to the direction X ($DX=0$)

To avoid the rigid movements of body, nodes A and P1 have same vertical displacement.

Loadings:

Following imposed displacement Y on all the nodes of the plate: DY vary 0 with 2,225 cm .
(the value of 4,45 cm is the vertical bringing together of the two symmetrical plates).

Note:

| The grid was carried out in cm .

4.2 Characteristics of the grid

The grid is in any point identical to the grid used for modeling A.

4.3 Sizes tested and results

Identification	Moments	Reference	% tolerance
force of reaction (N)	1.	- 8.01	10
force of reaction (N)	2.	- 16.02	5
force of reaction (N)	3.	- 24.02	2
force of reaction (N)	4.	- 32.03	3
DX (GROUP_NO=' OF') (cm)	2.	NON_REGRESSION	
DX (GROUP_NO=' OF') (cm)	4.		
SIXX (GROUP_NO=' A') (N/cm^2)	2.		
SIXX (GROUP_NO=' A') (N/cm^2)	4.		

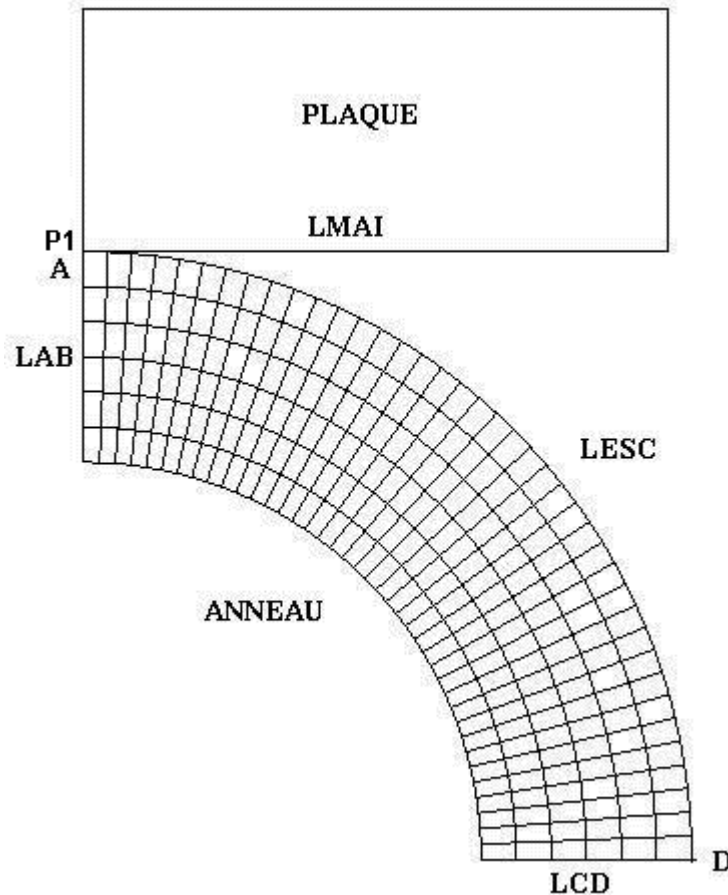
4.4 Remarks

The results are almost identical to those of modeling A.

5 Modeling C

5.1 Characteristics of modeling

A modeling testing the features of contact nodes - meshes (DEFI_CONTACT) without friction treated with the method of the active constraints was put in work. Taking into account the symmetry of the problem, it understands a quarter of the ring as well as the grid of an indeformable plate.



Boundary condition:

Conditions of symmetry: nodes of the group *LAB* located in the plan $X=0$ are blocked according to the direction X ($DX=0$),
nodes of the group *LCD* located in the plan $Y=0$ are blocked according to the direction Y ($DY=0$),
all nodes of the group of mesh « *Plaque* » are blocked according to the direction X ($DX=0$)

To avoid the rigid movements of body, the nodes *A* and *PI* have same vertical displacement.

Loadings:

Following imposed displacement Y on all the nodes of the plate: DY vary 0 with $2,225\text{ cm}$.
(The value of $4,45\text{ cm}$ is the vertical bringing together of the two symmetrical plates).

Note:

| The grid was carried out in cm .

5.2 Characteristics of the grid

The grid is resulting from the file "ssnp501b.mail" in which meshes of ends A and D were withdrawn from the group of mesh $LESC$.

5.3 Sizes tested and results

Identification	Moments	Reference	% tolerance
force of reaction (N)	1.	- 8.01	10
force of reaction (N)	2.	- 16.02	5
force of reaction (N)	3.	- 24.02	2
force of reaction (N)	4.	- 32.03	3
DX (GROUP_NO=' OF) (cm)	2.	NON_REGRESSION	
DX (GROUP_NO=' OF) (cm)	4.		
SIXX (GROUP_NO=' A ') (N/cm^2)	2.		
SIXX (GROUP_NO=' A ') (N/cm^2)	4.		

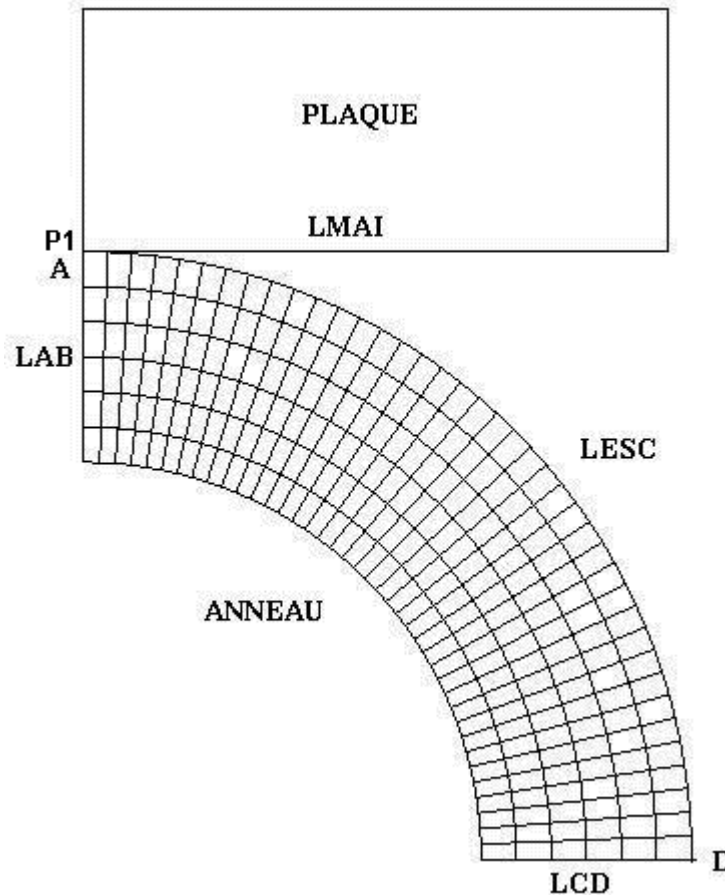
5.4 Remarks

The results are very close to those to modelings A and B.

6 Modeling D

6.1 Characteristics of modeling

A modeling testing the features of contact nodes - meshes (DEFI_CONTACT) without friction treated with the method GCP was put in work. Taking into account the symmetry of the problem, it understands a quarter of the ring as well as the grid of an indeformable plate.



Boundary condition:

Conditions of symmetry: nodes of the group *LAB* located in the plan $X=0$ are blocked according to the direction X ($DX=0$),
nodes of the group *LCD* located in the plan $Y=0$ are blocked according to the direction Y ($DY=0$),
all nodes of the group of mesh « *Plaque* » are blocked according to the direction X ($DX=0$)

To avoid the rigid movements of body, nodes A and P1 have same vertical displacement.

Loadings:

Following imposed displacement Y on all the nodes of the plate: DY vary 0 with 2,225 cm .
(the value of 4,45 cm is the vertical bringing together of the two symmetrical plates).

Note:

| The grid was carried out in cm .

6.2 Characteristics of the grid

The grid is in any point identical to the grid used for modeling A.

6.3 Sizes tested and results

Identification	Moments	Reference	% tolerance
force of reaction (N)	1.	- 8.01	10
force of reaction (N)	2.	- 16.02	5
force of reaction (N)	3.	- 24.02	2
force of reaction (N)	4.	- 32.03	3
DX (GROUP_NO=' OF') (cm)	2.	NON_REGRESSION	
DX (GROUP_NO=' OF') (cm)	4.		
SIXX (GROUP_NO=' A') (N/cm^2)	2.		
SIXX (GROUP_NO=' A') (N/cm^2)	4.		

6.4 Remarks

The results are almost identical to those of modeling A and B.

7 Summary of the results

Whatever the type of modeling of the zone of contact, the got results are satisfactory. The variations observed on the force of reaction are weak. But the values of reference are very approximate because they are extracted from a curved paper.

The grid of the code computer taken in reference and that used by Aster are different. Moreover, he is not explained in the reference how is extracted the normal pressure from contact. Thus, it was not carried out tests of reference on this pressure. However tests of not-regression are carried out on the contact pressure ($SIYY$ with the node in contact). The pace of this pressure and the zone of contact are identical between the two computer codes.