# SSNP502 - Crushing of a polyurethane ring between two indeformable plates with friction

**Summary:**

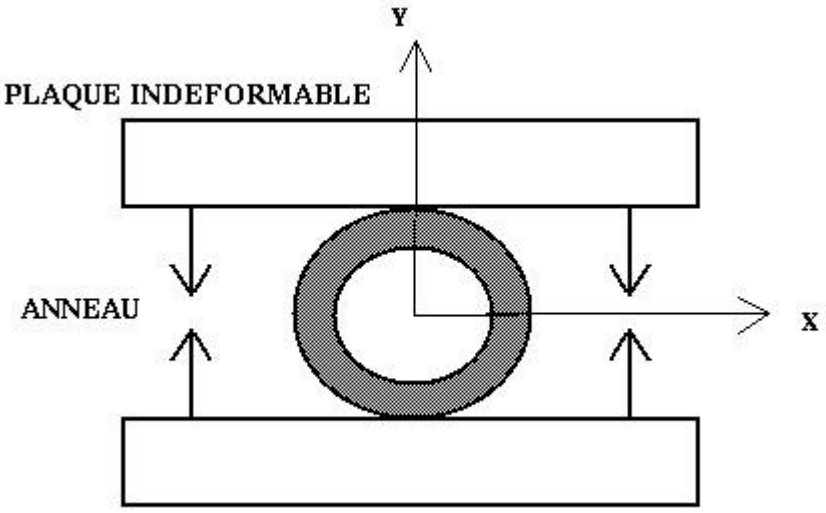
The test consists in simulating crushing in plane constraints of an elastic circular polyurethane ring by two indeformable symmetrical plates. The objective is to test the features related to the contact. This test comprises a sticking together on a zone of contact important length with the presence 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 three modelings suggested, the ring is modelled with meshs QUAD4 in plane constraints:

- **modeling B**, a contact **with friction** treated with the method of penalization was defined between the plate and the ring,
- **modeling C**, a contact **with friction** treated with the method continues 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: | $E=407\,N/cm^2$ |
| Poisson's ratio: | $\nu=0,48$ |
| Coefficient of friction: | $\mu=0,4$ |

## 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 ( $cm$ ) | Force of reaction ( $N$ ) |
|---|---|
| 1.1125 | 8.0083 |
| 2.2250 | 16.0166 |
| 3.3375 | 24.0250 |
| 4.4500 | 32.0333 |

The normal pressure of contact is bench-mark datum. But, the grids used are different. This pressure will be used to define tests of not-regression.

## 2.3 Uncertainties on the solution

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

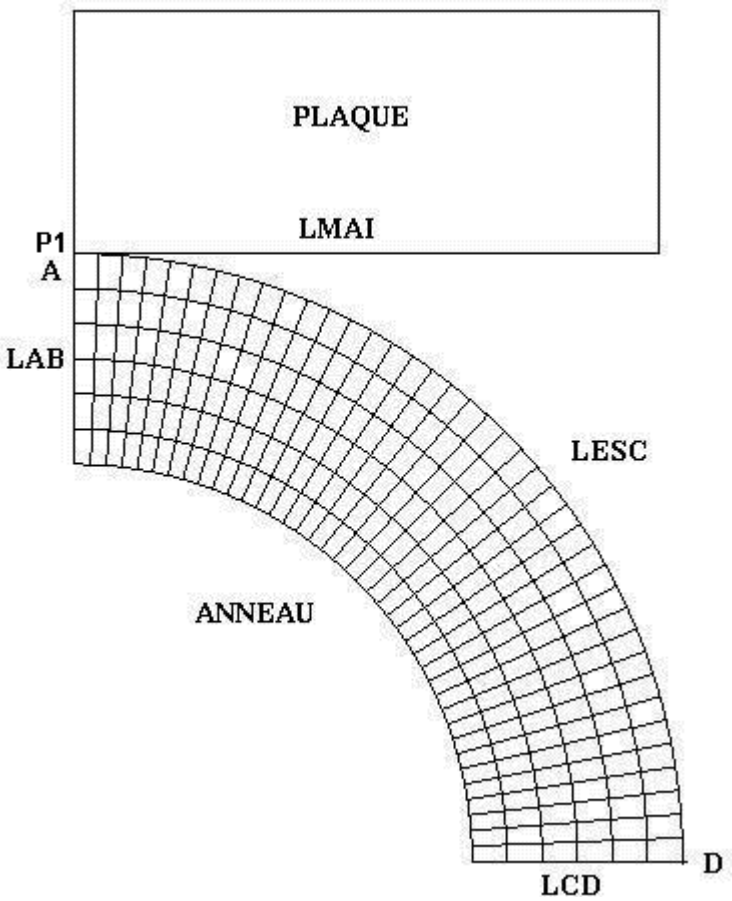
## 2.4 Bibliographical references

- 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 B

## 3.1 Characteristics of modeling

A modeling testing the features of contact with friction treated with the method of penalization 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 $P1$ have even 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 $cm$ .*

## 3.2 Characteristics of the grid

Many nodes: 291
Number of meshs and type: 241 QUAD4 and 51 SEG2

## 3.3 Sizes tested and results

| Identification | Displacement | Reference | Type of reference | Tolerance |
|---|---|---|---|---|
| Force of reaction ( $N$ ) | $1,1125\,cm$ | – 8.01 | 'SOURCE_EXTERNE' | 11, 000% |
| Force of reaction ( $N$ ) | $2,2250\,cm$ | – 16.02 | 'SOURCE_EXTERNE' | 7, 000% |
| Force of reaction ( $N$ ) | $3,3375\,cm$ | – 24.02 | 'SOURCE_EXTERNE' | 4, 000% |
| Force of reaction ( $N$ ) | $4,4500\,cm$ | – 32.03 | 'SOURCE_EXTERNE' | 5.000% |
| Displacement in $D$ ( $cm$ ) | $2,2250\,cm$ | | 'NON_REGRESSION' | |
| Displacement in $D$ ( $cm$ ) | $4,4500\,cm$ | | 'NON_REGRESSION' | |
| Contact pressure in A ( $N.cm^{-2}$ ) | $2,2250\,cm$ | | 'NON_REGRESSION' | |
| Contact pressure in A ( $N.cm^{-2}$ ) | $4,4500\,cm$ | | 'NON_REGRESSION' | |

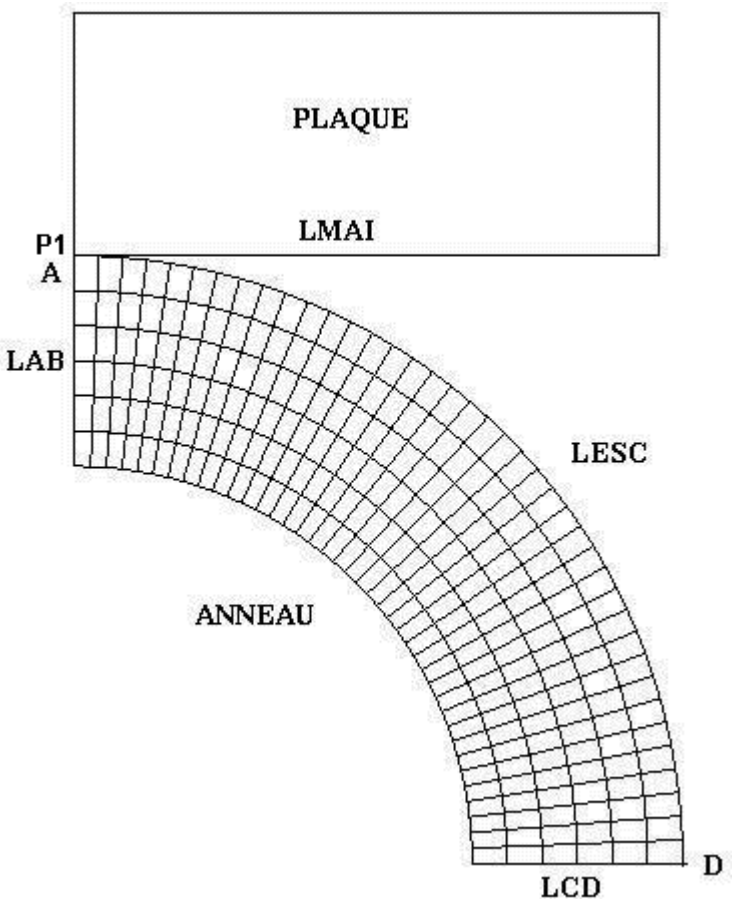
## 3.4 Remarks

One can visualize the influence of friction by looking at the shear stress to the nodes in contact. The difference should be made enters $SIXY$ with friction and $SIXY$ without friction to eliminate the problems of averages on the nodes of the edge.

# 4 Modeling C

## 4.1 Characteristics of modeling

A modeling testing the features of contact with friction treated with the method continues 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 $P1$ 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 bringing together vertical 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 B.

## 4.3 Sizes tested and results

| Identification | Displacement | Reference | Type of reference | Tolerance |
|---|---|---|---|---|
| Force of reaction ( $N$ ) | $1,1125\,cm$ | – 8.01 | 'SOURCE_EXTERNE' | 11, 000% |
| Force of reaction ( $N$ ) | $2,2250\,cm$ | – 16.02 | 'SOURCE_EXTERNE' | 7, 000% |
| Force of reaction ( $N$ ) | $3,3375\,cm$ | – 24.02 | 'SOURCE_EXTERNE' | 4, 000% |
| Force of reaction ( $N$ ) | $4,4500\,cm$ | – 32.03 | 'SOURCE_EXTERNE' | 5, 000% |
| Displacement in $D$ ( $cm$ ) | $2,2250\,cm$ | | 'NON_REGRESSION' | |
| Displacement in $D$ ( $cm$ ) | $4,4500\,cm$ | | 'NON_REGRESSION' | |
| Contact pressure in A ( $N.cm^{-2}$ ) | $2,2250\,cm$ | | 'NON_REGRESSION' | |
| Contact pressure in A ( $N.cm^{-2}$ ) | $4,4500\,cm$ | | 'NON_REGRESSION' | |

## 4.4 Notice

The results are very close to those of modeling B.

# 5 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.