
SSNV503 - Shoe slipping on a rigid level

Summary:

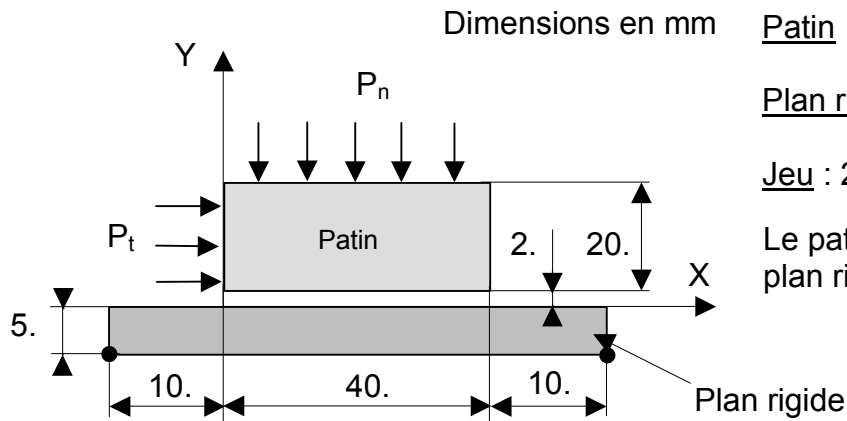
This test represents a calculation of contact of a shoe slipping on a rigid level. The objective of this test is to make it possible to validate in an unquestionable way calculation of the criterion of Coulomb and the good transmission of the pressure.

Various modelings of the zone of contact tested are the following ones:

- **Modeling A** (2D): contact node-mesh, Lagrangian method for the contact and friction, geometrical game.
- **Modeling B** (2D): contact node-mesh with Lagrangian method and game defined by a function.
- **Modeling C** (2D): contact node-mesh, method Lagrangian for the contact and penalized for friction, geometrical game.
- **Modeling D** (2D): contact node-mesh, method penalized for the contact and friction, geometrical game.
- **Modeling E** (3D): contact node-mesh, method Lagrangian for the contact and penalized for friction, geometrical game.
- **Modeling F** (3D): contact node-mesh, method Lagrangian for the contact and penalized for friction, game defined by a function.
- **Modeling G** (3D): contact node-mesh, method penalized for the contact and friction, geometrical game.
- **Modeling H** (2D): contact node-mesh, method continues for the contact and friction, game geometrical.
- **Modeling I** (3D): contact node-mesh, method continues for the contact and friction, game geometrical.
- **Modeling J** (2D): contact by elements of joint, law JOINT_MECA_FROT

1 Problem of reference

1.1 Geometry



Patin : épaisseur = 20.mm
 largeur = 20.mm
Plan rigide : épaisseur = 5.mm
 largeur = 60.mm

Jeu : 2.mm

Le patin est situé au milieu du plan rigide

1.2 Properties of material

Shoe:

$E = 2.1106 \text{ N/mm}^2$ Young modulus
 $\nu = 0$ Poisson's ratio

Rigid plan by conditions kinematics.

Zone of contact:

$\mu = 0.3$ Coefficient of friction

1.3 Boundary conditions and loadings

Boundary conditions:

- All the nodes of the rigid plan are embedded.

3 cases of loading:

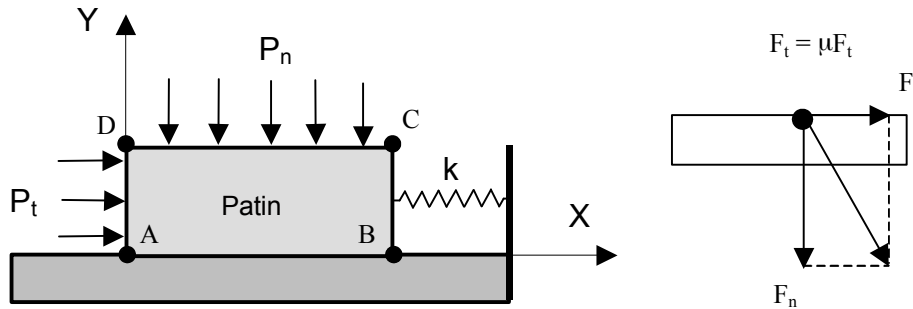
- Normal pressure $P_n = 300 \text{ N/mm}^2$
- Normal pressure $P_n = 300 \text{ N/mm}^2$ and tangential pressure $P_t = 178.2 \text{ N/mm}^2$
- Normal pressure $P_n = 300 \text{ N/mm}^2$ and tangential pressure $P_t = 181.8 \text{ N/mm}^2$

1.4 Initial conditions

None.

2 Reference solution

2.1 Method of calculating used for the reference solution



Design assumption: The deformation of the shoe is neglected.

Loading 1 – normal Pressure $P_n: 300\text{N}/\text{mm}^2$

One checks:

1. Good transmission of the normal efforts on the level of the zone of contact: the normal pressure on the level of the zone of contact is equal to the pressure applied ($P_n = P_n^{\text{contact}}$)
2. That the vertical displacement of the shoe on the level of the zone of contact AB is equal to the game.

Loading 2 – normal Pressure $P_n: 300\text{N}/\text{mm}^2$ **and tangential pressure** $P_t=178.2\text{N}/\text{mm}^2$

It is a situation of adherence. It is checked that nodes of the shoe located in the zone of slip (AB)

do not move tangentially: $P_t = \frac{\mu P_n S_{CD}}{S_{AD}} 0.99$

Loading 3 – normal Pressure $P_n: 300\text{N}/\text{mm}^2$ **and tangential pressure** $P_t=181.8\text{N}/\text{mm}^2$

It is a situation of slip. It is checked that nodes of the shoe located in the zone of slip (AB) move

9mm according to X : $P_t = \frac{\mu P_n S_{CD}}{S_{AD}} 1.01$

Determination of the stiffness k spring: one wants to determine the stiffness of the spring according to desired displacement. At the time of the slip, the force in the spring is of:

$$F_r = F_t - \mu F_n = 0,01 \mu F_n \quad \text{with } (F_t = 181.8 \times 20, F_n = 300 \times 40)$$

$F_r = K U_t$:	force in the spring
$F_t = P_t \times S_{AD}$:	tangential force
$F_n = P_n \times S_{CD}$:	normal force
U_t	:	tangential displacement
S_{AD}	:	surface
S_{DC}	:	surface

For a displacement of 9.mm rigidity k spring must-being of $0.01 \mu F_n / 9 = 4 \text{N}/\text{mm}$

2.2 Results of reference

- **Loading 1 (normal Pressure P_n): $P_n^{contact} = 300N/mm^2$**
- **Loading 2 ($P_n: 300N/mm^2$ and $P_t = 178.2N/mm^2$):** it is checked that there exists at least a node of the surface of contact which does not slip. One test that at least one of the nodes located on the face opposed to the application of the side loading does not slip.
- **Loading 3 ($P_n: 300N/mm^2$ and $P_t = 181.8N/mm^2$):** it is checked that all the nodes of the surface of contact slip. One tests that all the nodes located on the face opposed to the application of the side loading slip.

2.3 Uncertainties on the solution

Lower than 0.1%

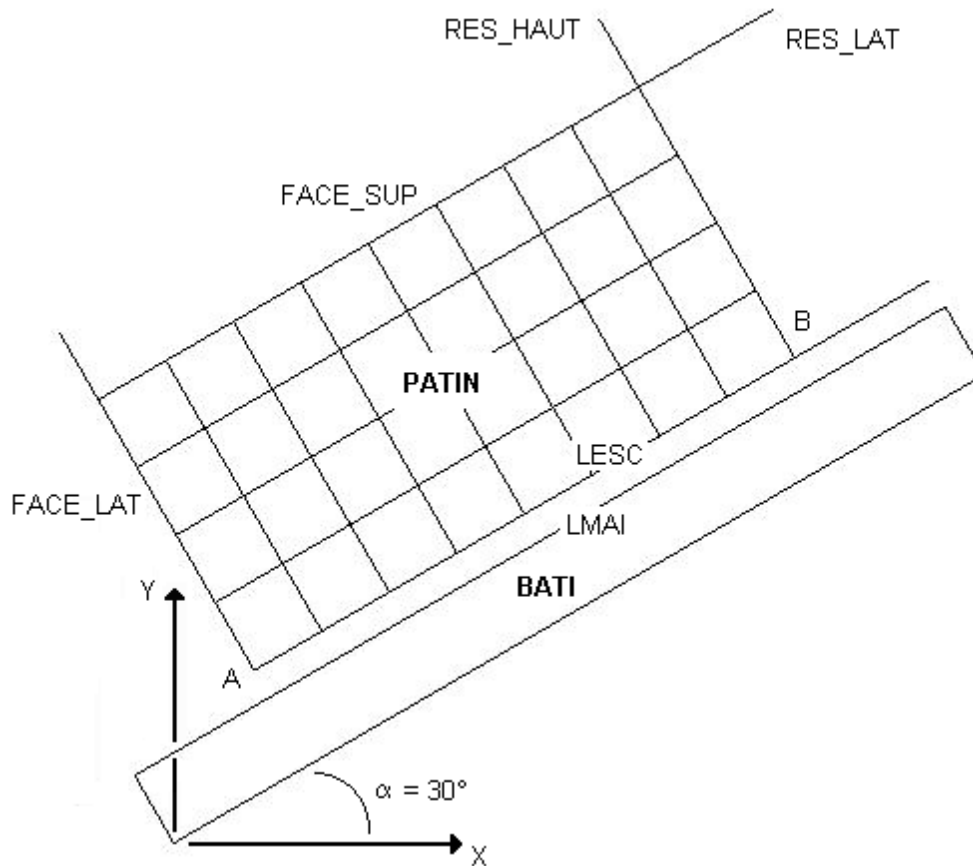
2.4 Bibliographical references

Without object

3 Modeling A

3.1 Characteristics of modeling

A modeling `D_PLAN` with elements `QUAD4` testing the features of contact node-mesh with friction treated with the Lagrangian method (discrete formulation) was put in work.



The game between the shoe and the frame is defined by the geometrical coordinates of the grid.

To avoid the movements of rigid body, the shoe is maintained by springs of low rigidity:

$$\begin{aligned} \text{RES_LAT} &: k = 2 \text{ N/mm} \\ \text{RES_HAUT} &: k = 0,005 \text{ N/mm} \end{aligned}$$

Boundary conditions:

$$\begin{aligned} \text{Loose lead of the springs: } &DX = DY = 0 . \\ \text{Frame: } &DX = DY = 0 . \end{aligned}$$

3.2 Characteristics of the grid

Many nodes: 53
Number and types of meshes: 33 QUAD4, 32 SEG2

4 Results of modeling A

4.1 Values tested

Identification	Reference	Type	Tolerance
Loading 1			
Normal force of contact	1,200E+04 NR	ANALYTICAL	RELATIVE - 5.00%
Tangential force of contact	0 NR	ANALYTICAL	ABSOLUTE - 5.00%
DX (not A)	1.000 mm	NON_REGRESSION	RELATIVE - 1.00%

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DY (not A)	- 1.732 mm	NON_REGRESSION	RELATIVE - 1.00%
DX (not B)	1.000 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not B)	- 1.732 mm	NON_REGRESSION	RELATIVE - 1.00%
Loading 2			
Normal force of contact	1,200E+04 NR	ANALYTICAL	RELATIVE - 5.00%
Tangential force of contact	- 3,564E+03 NR	ANALYTICAL	RELATIVE - 5.00%
DX (not A)	1.000 mm	NON_REGRESSION	RELATIVE - 2.3 0%
DY (not A)	- 1.732 mm	NON_REGRESSION	RELATIVE - 1.00%
DX (not B)	1.000 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not B)	- 1.732 mm	NON_REGRESSION	RELATIVE - 1.00%
Loading 3			
Normal force of contact	1,200E+04 NR	ANALYTICAL	RELATIVE - 5.00%
Tangential force of contact	- 3,624E+03 NR	ANALYTICAL	RELATIVE - 5.00%
DX (not A)	8.787 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not A)	2.768 mm	NON_REGRESSION	RELATIVE - 1.00%
DX (not B)	8.787 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not B)	2.768 mm	NON_REGRESSION	RELATIVE - 1.00%

4.2 Remarks

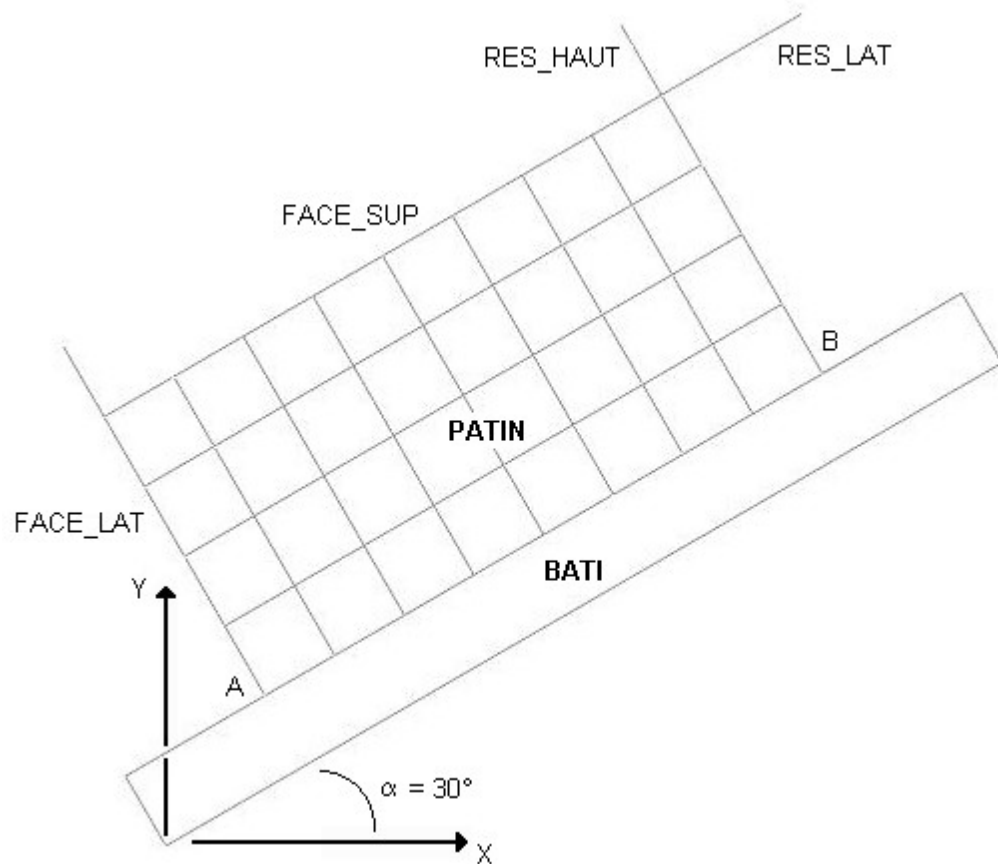
- The game is defined in this case in a geometrical way. There is the possibility of defining it via the keywords `DIST_1` and `DIST_2`. This is done in the following model.
- The pressures normal and tangential on the level of the zone of contact are checked by testing the total force of contact in the normal and tangential direction:

$$\begin{aligned}F_n^{CTAC} &= p_n S_{DC} = 300 * 40 * 1 = 12000 N \\F_t^{CTAC} &= p_t S_{AD} = 178.2 * 20 * 1 = 35640 N \quad (\text{Chargement 2}) \\F_t^{CTAC} &= p_t S_{AD} = 181.8 * 20 * 1 = 36240 N \quad (\text{Chargement 3})\end{aligned}$$

5 Modeling B

5.1 Characteristics of modeling

A modeling `D_PLAN` with elements `QUAD4` testing the features of contact node-mesh with friction treated with the Lagrangian method was put in work.



The game between the shoe and the frame is defined by a function using the keyword " DIST_2 ".

To avoid the movements of rigid body, the shoe is maintained by springs of low rigidity:

RES_LAT : $k = 2 \text{ N/mm}$
RES_HAUT : $k = 0,005 \text{ N/mm}$

Boundary conditions:

Loose lead of the springs: $DX = DY = 0$.
Frame: $DX = DY = 0$.

5.2 Characteristics of the grid

Many nodes: 53
Number and types of meshes: 33 QUAD4 , 32 SEG2

6 Results of modeling B

6.1 Values tested

Identification	Reference	Type	Tolerance
Loading 1			
Normal force of contact	1,200E+04 NR	ANALYTICAL	RELATIVE - 5.00%
Tangential force of contact	0 NR	ANALYTICAL	ABSOLUTE - 5.00%
DX (not A)	1.000 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not A)	- 1.732 mm	NON_REGRESSION	RELATIVE - 1.00%

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DX (not B)	1.000 mm	NON_REGRESSION	RELATIVE – 1.00%
DY (not B)	– 1.732 mm	NON_REGRESSION	RELATIVE – 1.00%
Loading 2			
Normal force of contact	1,200E+04 NR	ANALYTICAL	RELATIVE – 5.00%
Tangential force of contact	– 3,564E+03 NR	ANALYTICAL	RELATIVE – 5.00%
DX (not A)	1.000 mm	NON_REGRESSION	RELATIVE – 2.3 0%
DY (not A)	– 1.732 mm	NON_REGRESSION	RELATIVE – 1.00%
DX (not B)	1.000 mm	NON_REGRESSION	RELATIVE – 1.00%
DY (not B)	– 1.732 mm	NON_REGRESSION	RELATIVE – 1.00%
Loading 3			
Normal force of contact	1,200E+04 NR	ANALYTICAL	RELATIVE – 5.00%
Tangential force of contact	– 3,624E+03 NR	ANALYTICAL	RELATIVE – 5.00%
DX (not A)	8.787 mm	NON_REGRESSION	RELATIVE – 1.00%
DY (not A)	2.768 mm	NON_REGRESSION	RELATIVE – 1.00%
DX (not B)	8.787 mm	NON_REGRESSION	RELATIVE – 1.00%
DY (not B)	2.768 mm	NON_REGRESSION	RELATIVE – 1.00%

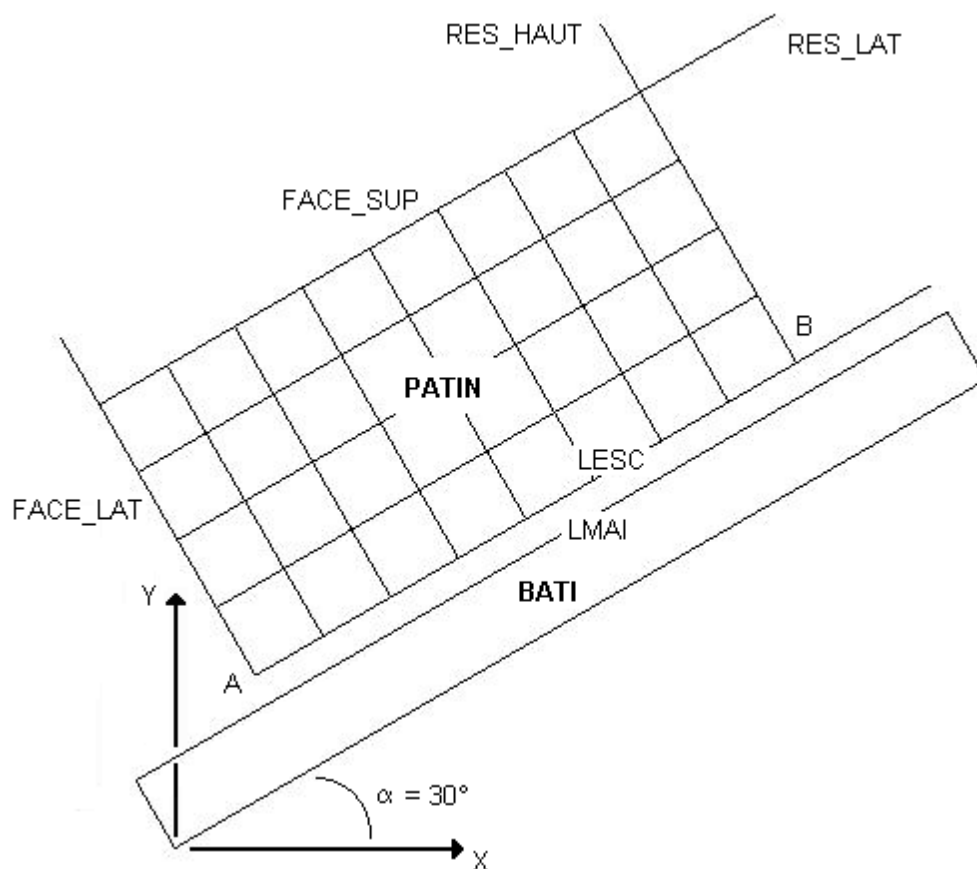
6.2 Notice

The game is defined in this case by a function. There is no difference with the preceding model where the game is defined in a geometrical way.

7 Modeling C

7.1 Characteristics of modeling

A modeling `D_PLAN` with elements `QUAD4` testing the features of contact node-mesh with friction treated with the method Lagrangian for the contact and penalized for friction was put in work.



The game between the shoe and the frame is defined by the geometrical coordinates of the grid.

To avoid the movements of rigid body, the shoe is maintained by springs of low rigidity:

RES_LAT : $k = 2 \text{ N/mm}$
RES_HAUT : $k = 0,005 \text{ N/mm}$

Boundary conditions:

Loose lead of the springs: $DX = DY = 0$.
Frame: $DX = DY = 0$.

7.2 Characteristics of the grid

Many nodes: 53
Number and types of meshes: 33 QUAD4, 32 SEG2

8 Results of modeling C

8.1 Values tested

Identification	Reference	Type	Tolerance
Loading 1			
Normal force of contact	1,200E+04 NR	ANALYTICAL	RELATIVE - 5.00%
Tangential force of contact	0 NR	ANALYTICAL	ABSOLUTE - 5.00%
DX (not A)	1.000 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not A)	- 1.732 mm	NON_REGRESSION	RELATIVE - 1.00%

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DX (not B)	1.000 mm	NON_REGRESSION	RELATIVE – 1.00%
DY (not B)	– 1.732 mm	NON_REGRESSION	RELATIVE – 1.00%
Loading 2			
Normal force of contact	1,200E+04 NR	ANALYTICAL	RELATIVE – 5.00%
Tangential force of contact	– 3,564E+03 NR	ANALYTICAL	RELATIVE – 5.00%
DX (not A)	1.000 mm	NON_REGRESSION	RELATIVE – 2.3 0%
DY (not A)	– 1.732 mm	NON_REGRESSION	RELATIVE – 1.00%
DX (not B)	1.000 mm	NON_REGRESSION	RELATIVE – 1.00%
DY (not B)	– 1.732 mm	NON_REGRESSION	RELATIVE – 1.00%
Loading 3			
Normal force of contact	1,200E+04 NR	ANALYTICAL	RELATIVE – 5.00%
Tangential force of contact	– 3,624E+03 NR	ANALYTICAL	RELATIVE – 5.00%
DX (not A)	8.787 mm	NON_REGRESSION	RELATIVE – 1.00%
DY (not A)	2.768 mm	NON_REGRESSION	RELATIVE – 1.00%
DX (not B)	8.787 mm	NON_REGRESSION	RELATIVE – 1.00%
DY (not B)	2.768 mm	NON_REGRESSION	RELATIVE – 1.00%

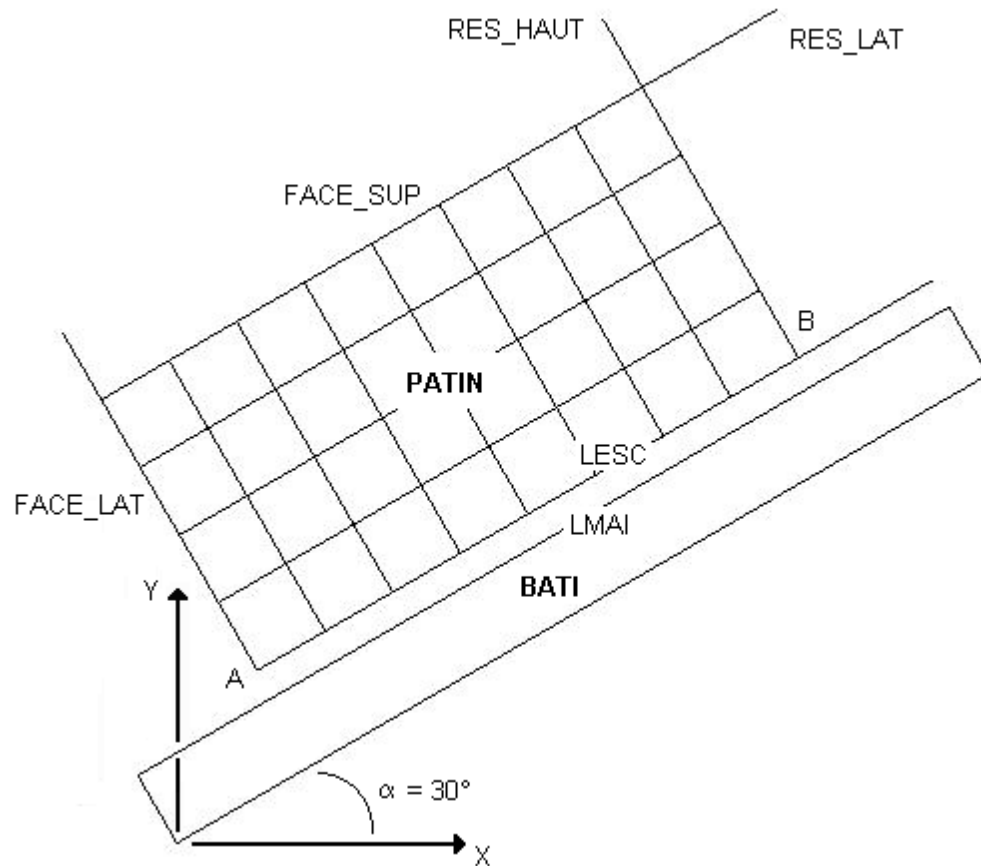
8.2 Notice

The game is defined in this case in a geometrical way. There is the possibility of defining it via the keywords `DIST_1` and `DIST_2`. After checking, this second case does not change anything with the result.

9 Modeling D

9.1 Characteristics of modeling

A modeling `D_PLAN` with elements `QUAD4` testing the features of contact node-mesh with friction treated with the method penalized for the contact and friction was put in work.



The game between the shoe and the frame is defined by the geometrical coordinates of the grid.

To avoid the movements of rigid body, the shoe is maintained by springs of low rigidity:

RES_LAT : $k = 2 \text{ N/mm}$
RES_HAUT : $k = 0,005 \text{ N/mm}$

Boundary conditions:

Loose lead of the springs: $DX = DY = 0$.
Frame: $DX = DY = 0$.

9.2 Characteristics of the grid

Many nodes: 53
Number and types of meshes: 33 QUAD4, 32 SEG2

10 Results of modeling D

10.1 Values tested

Identification	Reference	Type	Tolerance
Loading 1			
Normal force of contact	1,200E+04 NR	ANALYTICAL	RELATIVE - 5.00%
Tangential force of contact	0 NR	ANALYTICAL	ABSOLUTE - 5.00%
DX (not A)	1.000 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not A)	- 1.732 mm	NON_REGRESSION	RELATIVE - 1.00%

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DX (not B)	1.000 mm	NON_REGRESSION	RELATIVE – 1.00%
DY (not B)	– 1.732 mm	NON_REGRESSION	RELATIVE – 1.00%
Loading 2			
Normal force of contact	1,200E+04 NR	ANALYTICAL	RELATIVE – 5.00%
Tangential force of contact	– 3,564E+03 NR	ANALYTICAL	RELATIVE – 5.00%
DX (not A)	1.000 mm	NON_REGRESSION	RELATIVE – 2, 6 0%
DY (not A)	– 1.732 mm	NON_REGRESSION	RELATIVE – 1.00%
DX (not B)	1.000 mm	NON_REGRESSION	RELATIVE – 1.00%
DY (not B)	– 1.732 mm	NON_REGRESSION	RELATIVE – 1.00%
Loading 3			
Normal force of contact	1,200E+04 NR	ANALYTICAL	RELATIVE – 5.00%
Tangential force of contact	– 3,624E+03 NR	ANALYTICAL	RELATIVE – 5.00%
DX (not A)	8.787 mm	NON_REGRESSION	RELATIVE – 1.00%
DY (not A)	2.768 mm	NON_REGRESSION	RELATIVE – 1.00%
DX (not B)	8.787 mm	NON_REGRESSION	RELATIVE – 1.00%
DY (not B)	2.768 mm	NON_REGRESSION	RELATIVE – 1.00%

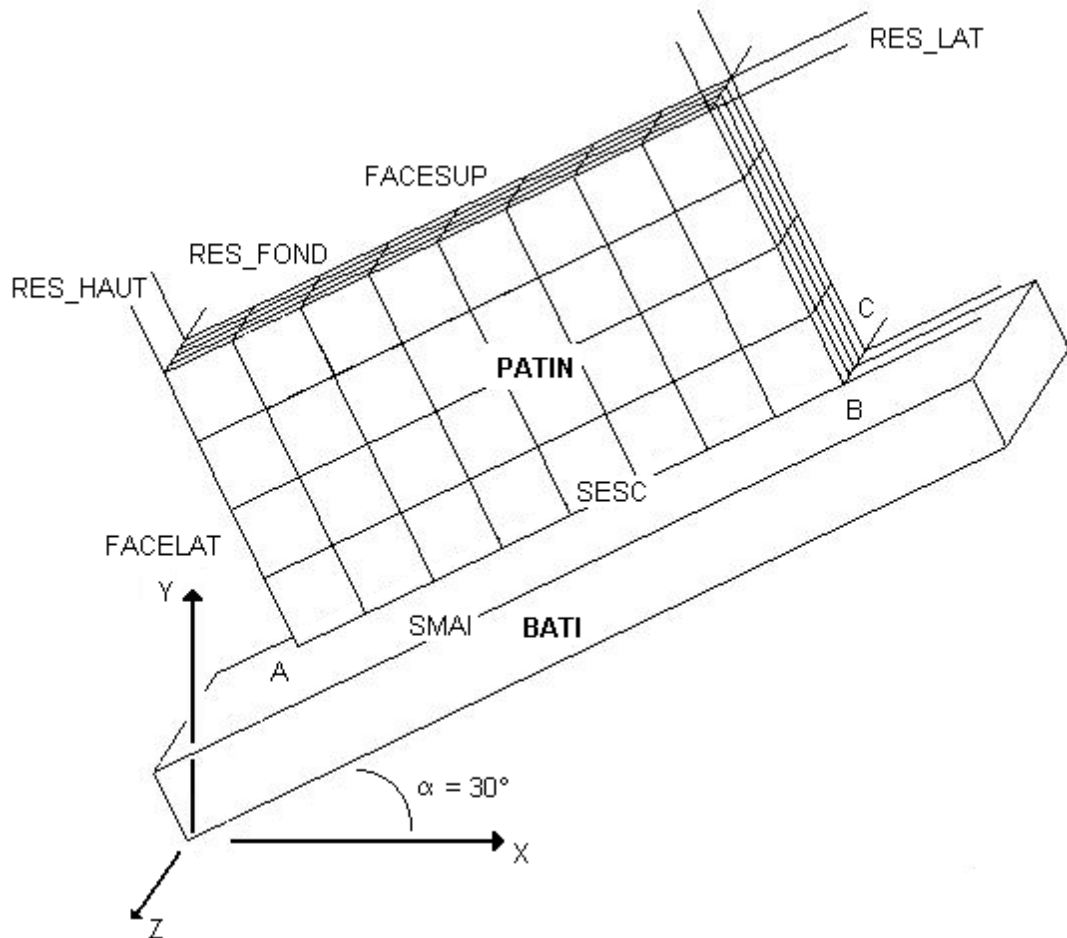
10.2 Notice

The game is defined in this case in a geometrical way. There is the possibility of defining it via the keywords `DIST_1` and `DIST_2`. After checking, this second case does not change anything with the result.

11 Modeling E

11.1 Characteristics of modeling

A modeling 3D with elements `HEXA8` testing the features of contact node-mesh with friction treated with the method Lagrangian for the contact and penalized for friction was put in work.



The game between the shoe and the frame is defined by the geometrical coordinates of the grid.

To avoid the movements of rigid body, the shoe is maintained by springs of low rigidity:

RES_LAT : $k = 1 \text{ N/mm}$
RES_FOND : $k = 1 \text{ N/mm}$
RES_HAUT : $k = 20 \text{ N/mm}$

Boundary conditions:

Loose lead of the springs: $DX = DY = DZ = 0$.

Frame: $DX = DY = DZ = 0$.

11.2 Characteristics of the grid

Many nodes: 269

Number and type of meshes: 129 HEXA8, 103 QUAD4

12 Results of modeling E

12.1 Values tested

Identification	Reference	Type	Tolerance
Loading 1			
Normal force of contact	2.0784E+05 NR	ANALYTICAL	RELATIVE - 5.00%

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Tangential force of contact	-1,2000E+05 NR	ANALYTICAL	RELATIVE - 5.00%
DX (not A)	1.000 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not A)	- 1.732 mm	NON_REGRESSION	RELATIVE - 1.00%
DX (not B)	1.000 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not B)	- 1.732 mm	NON_REGRESSION	RELATIVE - 1.00%
DX (not C)	1.000 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not C)	- 1.732 mm	NON_REGRESSION	RELATIVE - 1.00%
DX (not D)	1.000 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not D)	- 1.732 mm	NON_REGRESSION	RELATIVE - 1.00%

Loading 2

Normal force of contact	1,722E+05 NR	ANALYTICAL	RELATIVE - 5.00%
Tangential force of contact	-1.8173E+05 NR	ANALYTICAL	RELATIVE - 5.00%
DX (not A)	1.000 mm	NON_REGRESSION	RELATIVE - 2, 6 0%
DY (not A)	- 1.732 mm	NON_REGRESSION	RELATIVE - 1.00%
DX (not B)	1.000 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not B)	- 1.732 mm	NON_REGRESSION	RELATIVE - 1.00%
DX (not C)	1.000 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not C)	- 1.732 mm	NON_REGRESSION	RELATIVE - 1.00%
DX (not D)	1.000 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not D)	- 1.732 mm	NON_REGRESSION	RELATIVE - 1.00%

Loading 3

Normal force of contact	1,71486E+05 NR	ANALYTICAL	RELATIVE - 5.00%
Tangential force of contact	-1,82977E+05 NR	ANALYTICAL	RELATIVE - 5.00%
DX (not A)	8.794 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not A)	2.768 mm	NON_REGRESSION	RELATIVE - 1.00%
DX (not B)	8.794 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not B)	2.768 mm	NON_REGRESSION	RELATIVE - 1.00%
DX (not C)	8.794 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not C)	2.768 mm	NON_REGRESSION	RELATIVE - 1.00%
DX (not D)	8.794 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not D)	2.768 mm	NON_REGRESSION	RELATIVE - 1.00%

12.2 Remarks

- The game is defined in this case in a geometrical way, the results are identical to those found in preceding modeling.
- The pressures normal and tangential on the level of the zone of contact are checked by testing the total force of contact in the normal and tangential direction:

$$F_n^{CTAC} = p_n S_{DC} = 300 \times 40 \times 20 = 240000 \text{N}$$

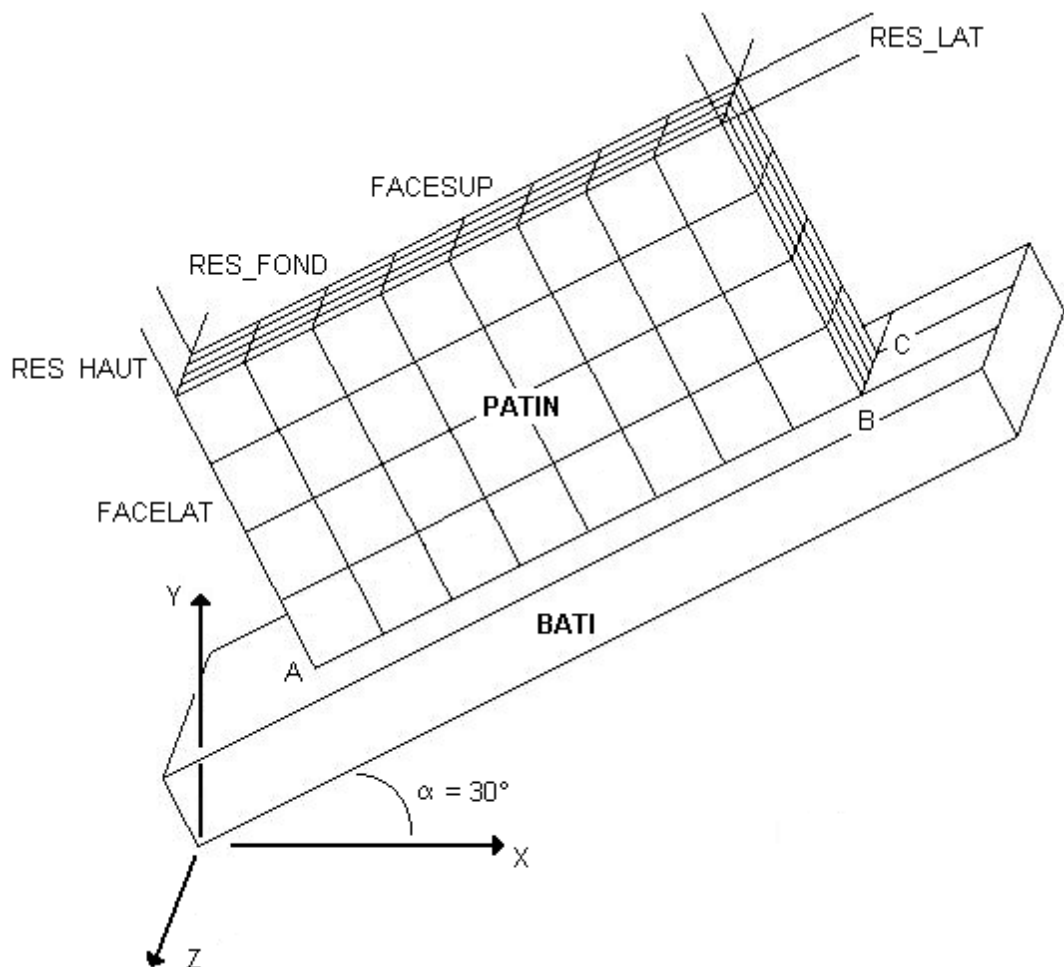
$$F_t^{CTAC} = p_t S_{AD} = 178.2 \times 20 \times 20 = 71280 \text{N (Loading 2)}$$

$$F_t^{CTAC} = p_t S_{AD} = 181.8 \times 20 \times 20 = 72720 \text{N (Loading 3)}$$

13 Modeling F

13.1 Characteristics of modeling

A modeling 3D with elements `HEXA8` testing the features of contact node-mesh with friction treated with the method Lagrangian for the contact and penalized for friction was put in work.



The game between the shoe and the frame is defined by the function using the keyword " `DIST_2` ".

To avoid the movements of rigid body, the shoe is maintained by springs of low rigidity:

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RES_HIGH : $k = 1 \text{ N/mm}$
RES_FOND : $k = 1 \text{ N/mm}$
RES_LAT : $k = 20 \text{ N/mm}$

Boundary conditions:

Loose lead of the springs: $DX = DY = DZ = 0$.

Frame: $DX = DY = DZ = 0$.

13.2 Characteristics of the grid

Many nodes: 269

Number and type of meshes: 129 HEXA8, 103 QUAD4

14 Results of modeling F

14.1 Values tested

Identification	Reference	Type	Tolerance
Loading 1			
Normal force of contact	2.0784E+05 NR	ANALYTICAL	RELATIVE - 5.00%
Tangential force of contact	-1,2000E+05 NR	ANALYTICAL	RELATIVE - 5.00%
DX (not A)	1.000 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not A)	- 1.732 mm	NON_REGRESSION	RELATIVE - 1.00%
DX (not B)	1.000 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not B)	- 1.732 mm	NON_REGRESSION	RELATIVE - 1.00%
DX (not C)	1.000 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not C)	- 1.732 mm	NON_REGRESSION	RELATIVE - 1.00%
DX (not D)	1.000 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not D)	- 1.732 mm	NON_REGRESSION	RELATIVE - 1.00%
Loading 2			
Normal force of contact	1,722E+05 NR	ANALYTICAL	RELATIVE - 5.00%
Tangential force of contact	-1.8173E+05 NR	ANALYTICAL	RELATIVE - 5.00%
DX (not A)	1.000 mm	NON_REGRESSION	RELATIVE - 2, 6 0%
DY (not A)	- 1.732 mm	NON_REGRESSION	RELATIVE - 1.00%
DX (not B)	1.000 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not B)	- 1.732 mm	NON_REGRESSION	RELATIVE - 1.00%
DX (not C)	1.000 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not C)	- 1.732 mm	NON_REGRESSION	RELATIVE - 1.00%
DX (not D)	1.000 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not D)	- 1.732 mm	NON_REGRESSION	RELATIVE - 1.00%
Loading 3			
Normal force of contact	1,71486E+05 NR	ANALYTICAL	RELATIVE - 5.00%
Tangential force of contact	-1,82977E+05 NR	ANALYTICAL	RELATIVE - 5.00%
DX (not A)	8.794 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not A)	2.768 mm	NON_REGRESSION	RELATIVE - 1.00%
DX (not B)	8.794 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not B)	2.768 mm	NON_REGRESSION	RELATIVE - 1.00%
DX (not C)	8.794 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not C)	2.768 mm	NON_REGRESSION	RELATIVE - 1.00%
DX (not D)	8.794 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not D)	2.768 mm	NON_REGRESSION	RELATIVE - 1.00%

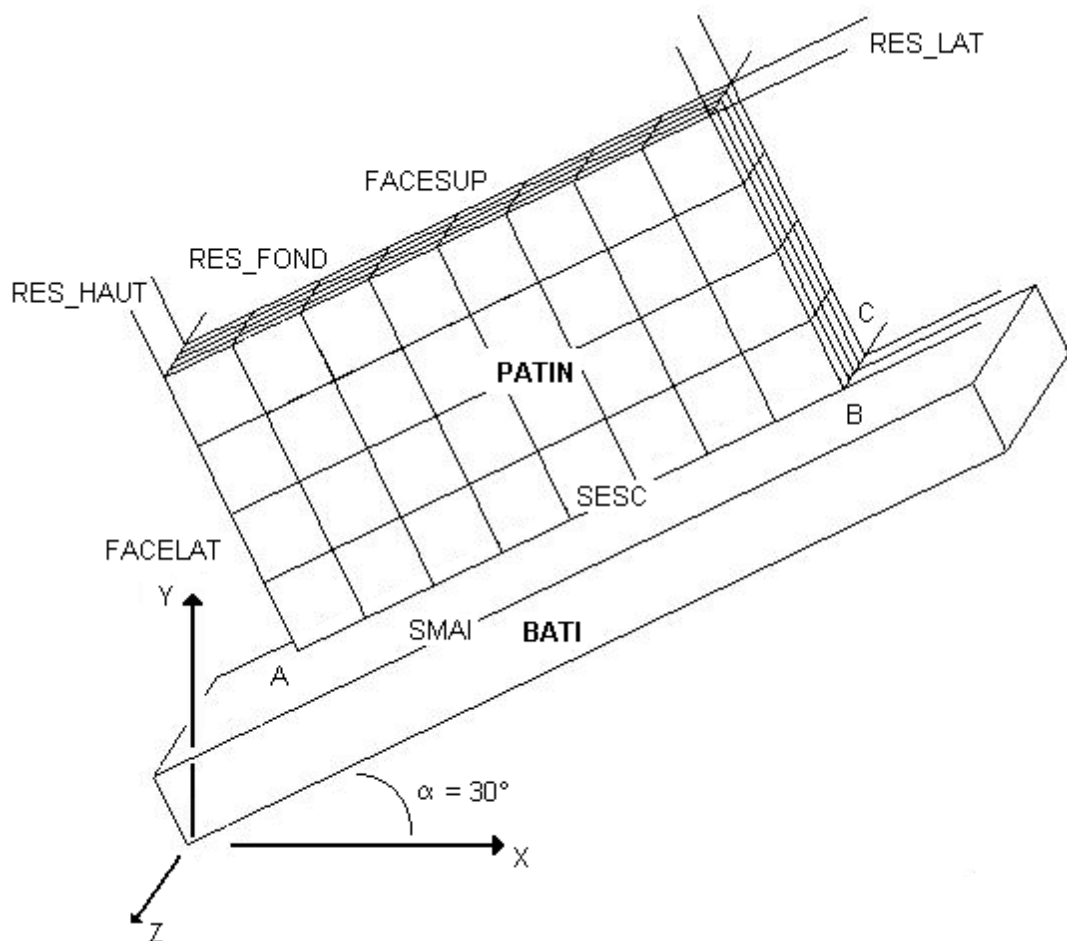
14.2 Notice

In this modeling, the game is defined using a function, the results are identical to those found in preceding modeling.

15 Modeling G

15.1 Characteristics of modeling

A modeling 3D with elements HEXA8 testing the features of contact node-mesh with friction treated with the method penalized for the contact and friction was put in work.



The game between the shoe and the frame is defined by the geometrical coordinates of the grid.

To avoid the movements of rigid body, the shoe is maintained by springs of low rigidity:

RES_HIGH : $k = 1 \text{ N/mm}$
RES_FOND : $k = 1 \text{ N/mm}$
RES_LAT : $k = 20 \text{ N/mm}$

Boundary conditions:

Loose lead of the springs: $DX = DY = DZ = 0$.
Frame: $DX = DY = DZ = 0$.

15.2 Characteristics of the grid

Many nodes: 269
Number and type of meshes: 129 HEXA8, 103 QUAD4

16 Results of modeling G

16.1 Values tested

Identification	Reference	Type	Tolerance
Loading 1			
Normal force of contact	2.0784E+05 NR	ANALYTICAL	RELATIVE – 5.00%
Tangential force of contact	-1,2000E+05 NR	ANALYTICAL	RELATIVE – 5.00%
DX (not A)	1.000 mm	NON_REGRESSION	RELATIVE – 1.00%
DY (not A)	- 1.732 mm	NON_REGRESSION	RELATIVE – 1.00%
DX (not B)	1.000 mm	NON_REGRESSION	RELATIVE – 1.00%
DY (not B)	- 1.732 mm	NON_REGRESSION	RELATIVE – 1.00%
DX (not C)	1.000 mm	NON_REGRESSION	RELATIVE – 1.00%
DY (not C)	- 1.732 mm	NON_REGRESSION	RELATIVE – 1.00%
DX (not D)	1.000 mm	NON_REGRESSION	RELATIVE – 1.00%
DY (not D)	- 1.732 mm	NON_REGRESSION	RELATIVE – 1.00%
Loading 2			
Normal force of contact	1,722E+05 NR	ANALYTICAL	RELATIVE – 5.00%
Tangential force of contact	-1.8173E+05 NR	ANALYTICAL	RELATIVE – 5.00%
DX (not A)	1.000 mm	NON_REGRESSION	RELATIVE – 2, 3 0%
DY (not A)	- 1.732 mm	NON_REGRESSION	RELATIVE – 1.00%
DX (not B)	1.000 mm	NON_REGRESSION	RELATIVE – 1.00%
DY (not B)	- 1.732 mm	NON_REGRESSION	RELATIVE – 1.00%
DX (not C)	1.000 mm	NON_REGRESSION	RELATIVE – 1.00%
DY (not C)	- 1.732 mm	NON_REGRESSION	RELATIVE – 1.00%
DX (not D)	1.000 mm	NON_REGRESSION	RELATIVE – 1.00%
DY (not D)	- 1.732 mm	NON_REGRESSION	RELATIVE – 1.00%
Loading 3			
Normal force of contact	1,71486E+05 NR	ANALYTICAL	RELATIVE – 5.00%
Tangential force of contact	-1,82977E+05 NR	ANALYTICAL	RELATIVE – 5.00%
DX (not A)	8.794 mm	NON_REGRESSION	RELATIVE – 1.00%
DY (not A)	2.768 mm	NON_REGRESSION	RELATIVE – 1.00%
DX (not B)	8.794 mm	NON_REGRESSION	RELATIVE – 1.00%
DY (not B)	2.768 mm	NON_REGRESSION	RELATIVE – 1.00%
DX (not C)	8.794 mm	NON_REGRESSION	RELATIVE – 1.00%
DY (not C)	2.768 mm	NON_REGRESSION	RELATIVE – 1.00%
DX (not D)	8.794 mm	NON_REGRESSION	RELATIVE – 1.00%
DY (not D)	2.768 mm	NON_REGRESSION	RELATIVE – 1.00%

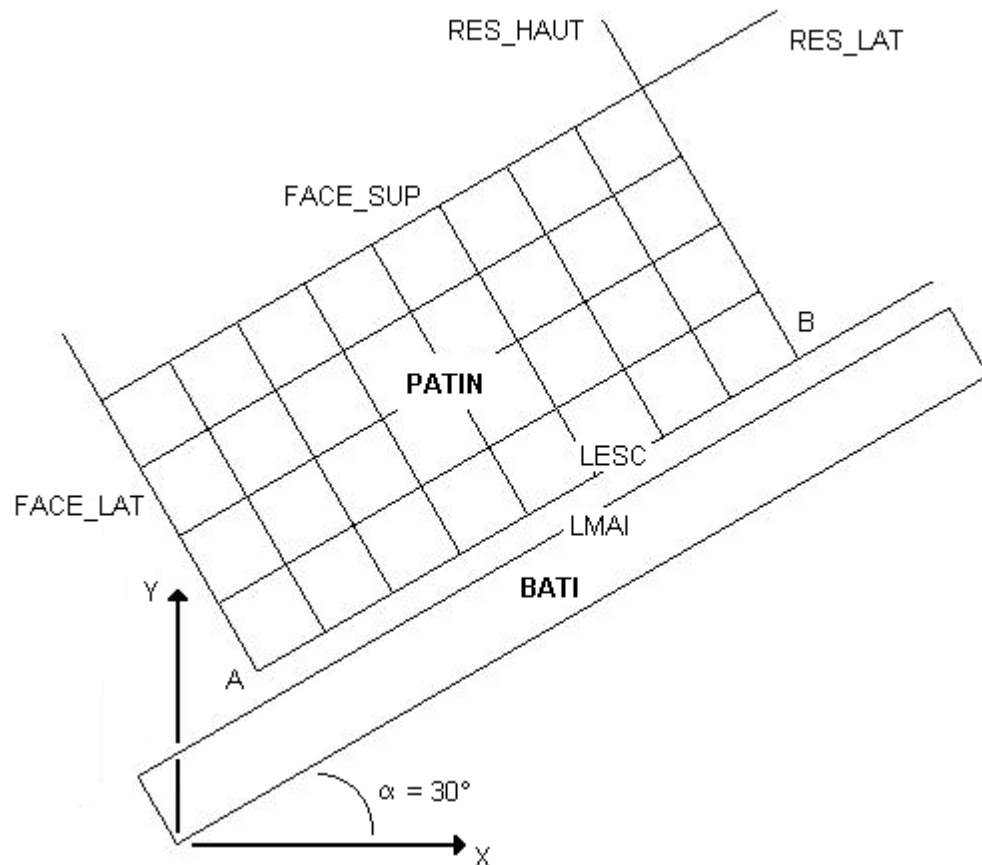
16.2 Notice

The game is defined in this case in a geometrical way. The results are less good than those obtained with the penalization only on friction. Moreover, this method is longer.

17 Modeling H

17.1 Characteristics of modeling

A modeling `D_PLANR` with elements `QUAD4` testing the features of contact node-mesh with friction treated with the method continues for the contact and friction was put in work.



The game between the shoe and the frame is defined by the geometrical coordinates of the grid.

To avoid the movements of rigid body, the shoe is maintained by springs of low rigidity:

`RES_LAT` : $k = 2 \text{ N/mm}$
`RES_HAUT` : $k = 0,005 \text{ N/mm}$

Boundary conditions:

Loose lead of the springs: $DX = DY = 0$.
Frame: $DX = DY = 0$.

17.2 Characteristics of the grid

Many nodes: 53
Number and types of meshes: 33 `QUAD4`, 32 `SEG2`

18 Results of modeling H

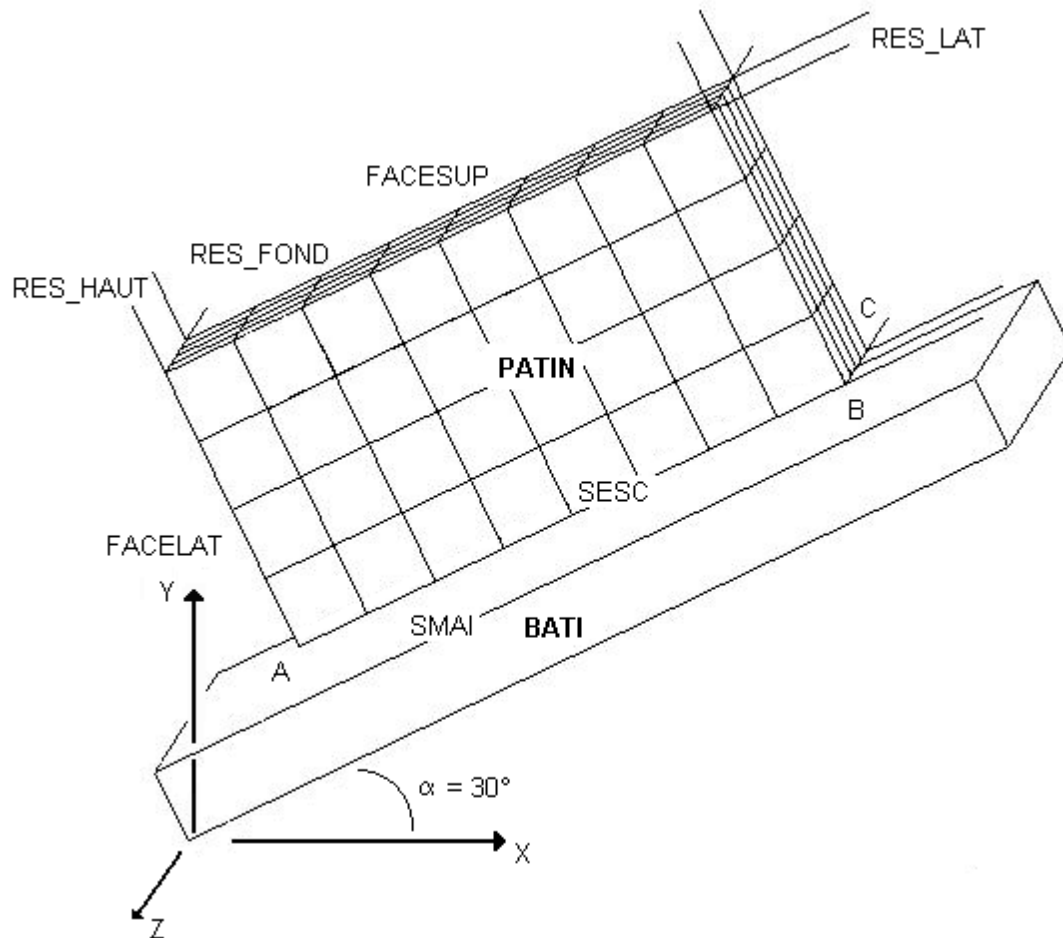
18.1 Values tested

Identification	Reference	Type	Tolerance
Loading 1			
Normal force of contact	1,200E+04 NR	ANALYTICAL	RELATIVE – 5.00%
Tangential force of contact	0 NR	ANALYTICAL	ABSOLUTE – 5.00%
DX (not A)	1.000 mm	NON_REGRESSION	RELATIVE – 1.00%
DY (not A)	– 1.732 mm	NON_REGRESSION	RELATIVE – 1.00%
DX (not B)	1.000 mm	NON_REGRESSION	RELATIVE – 1.00%
DY (not B)	– 1.732 mm	NON_REGRESSION	RELATIVE – 1.00%
Loading 2			
Normal force of contact	1,200E+04 NR	ANALYTICAL	RELATIVE – 5.00%
Tangential force of contact	– 3,564E+03 NR	ANALYTICAL	RELATIVE – 5.00%
DX (not A)	1.000 mm	NON_REGRESSION	RELATIVE – 2, 6 0%
DY (not A)	– 1.732 mm	NON_REGRESSION	RELATIVE – 1.00%
DX (not B)	1.000 mm	NON_REGRESSION	RELATIVE – 1.00%
DY (not B)	– 1.732 mm	NON_REGRESSION	RELATIVE – 1.00%
Loading 3			
Normal force of contact	1,200E+04 NR	ANALYTICAL	RELATIVE – 5.00%
Tangential force of contact	– 3,624E+03 NR	ANALYTICAL	RELATIVE – 5.00%
DX (not A)	8.787 mm	NON_REGRESSION	RELATIVE – 1.00%
DY (not A)	2.768 mm	NON_REGRESSION	RELATIVE – 1.00%
DX (not B)	8.787 mm	NON_REGRESSION	RELATIVE – 1.00%
DY (not B)	2.768 mm	NON_REGRESSION	RELATIVE – 1.00%

19 Modeling I

19.1 Characteristics of modeling

A modeling 3D with elements HEXA 8 testing the features of contact node-mesh with friction treated with the method continues for the contact and friction was put in work.



The game between the shoe and the frame is defined by the geometrical coordinates of the grid.

To avoid the movements of rigid body, the shoe is maintained by springs of low rigidity:

RES_HIGH : $k = 1 \text{ N/mm}$
RES_FOND : $k = 1 \text{ N/mm}$
RES_LAT : $k = 20 \text{ N/mm}$

Boundary conditions:

Loose lead of the springs: $DX = DY = DZ = 0$.
Frame: $DX = DY = DZ = 0$.

19.2 Characteristics of the grid

Many nodes: 269
Number and type of meshes: 129 HEXA8, 103 QUAD4

20 Results of modeling I

20.1 Values tested

Identification	Reference	Type	Tolerance
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Loading 1

Normal force of contact	2.0784E+05 NR	ANALYTICAL	RELATIVE - 5.00%
Tangential force of contact	-1,2000E+05 NR	ANALYTICAL	RELATIVE - 5.00%
DX (not A)	1.000 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not A)	- 1.732 mm	NON_REGRESSION	RELATIVE - 1.00%
DX (not B)	1.000 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not B)	- 1.732 mm	NON_REGRESSION	RELATIVE - 1.00%
DX (not C)	1.000 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not C)	- 1.732 mm	NON_REGRESSION	RELATIVE - 1.00%
DX (not D)	1.000 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not D)	- 1.732 mm	NON_REGRESSION	RELATIVE - 1.00%

Loading 2

Normal force of contact	1,722E+05 NR	ANALYTICAL	RELATIVE - 5.00%
Tangential force of contact	-1.8173E+05 NR	ANALYTICAL	RELATIVE - 5.00%
DX (not A)	1.000 mm	NON_REGRESSION	RELATIVE - 2, 3 0%
DY (not A)	- 1.732 mm	NON_REGRESSION	RELATIVE - 1.00%
DX (not B)	1.000 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not B)	- 1.732 mm	NON_REGRESSION	RELATIVE - 1.00%
DX (not C)	1.000 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not C)	- 1.732 mm	NON_REGRESSION	RELATIVE - 1.00%
DX (not D)	1.000 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not D)	- 1.732 mm	NON_REGRESSION	RELATIVE - 1.00%

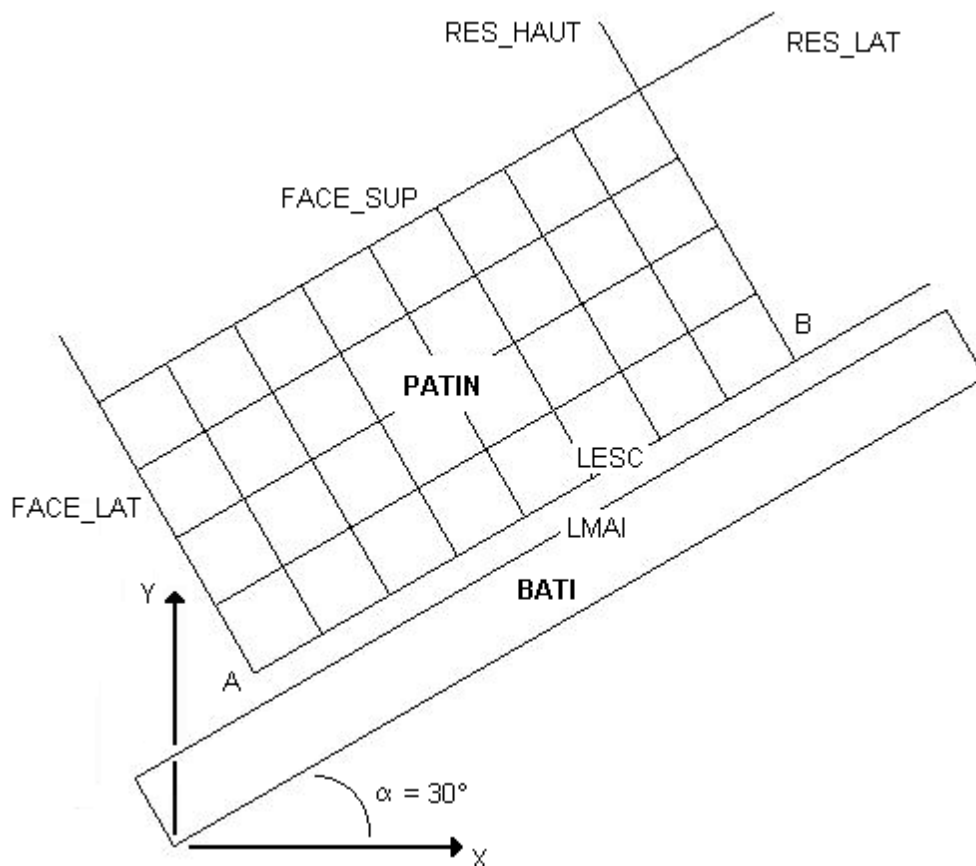
Loading 3

Normal force of contact	1,71486E+05 NR	ANALYTICAL	RELATIVE - 5.00%
Tangential force of contact	-1,82977E+05 NR	ANALYTICAL	RELATIVE - 5.00%
DX (not A)	8.794 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not A)	2.768 mm	NON_REGRESSION	RELATIVE - 1.00%
DX (not B)	8.794 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not B)	2.768 mm	NON_REGRESSION	RELATIVE - 1.00%
DX (not C)	8.794 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not C)	2.768 mm	NON_REGRESSION	RELATIVE - 1.00%
DX (not D)	8.794 mm	NON_REGRESSION	RELATIVE - 1.00%
DY (not D)	2.768 mm	NON_REGRESSION	RELATIVE - 1.00%

21 Modeling J

21.1 Characteristics of modeling

A simulation in flat deformations is carried out: a modeling with elements QUAD4 in D_PLA NR for the meshes of the SHOE and FRAME and D_PLA N_JOINT for joint FISS. One tests the features of contact penalized in compression with friction treated via a law of behavior JOIN_MECA_FROT.



The game between the shoe and the frame is defined only for the visualization of the contact, it does not influence the results physique (characteristic of modeling of joint). The parameter of regularization of the law east chooses of kind not to influence not (less than 0.01%) the replacement final one of shoe in glissement.

K_N : $K_n = 10^5 \text{ N/mm}^3$ parameter of penalization in compression and slip

To avoid the movements of rigid body, the shoe is maintained by springs of low rigidity:

RES_LAT : $k = 2 \text{ N/mm}$
RES_HAUT : $k = 0,005 \text{ N/mm}$

Boundary conditions:

Loose lead of the springs: $DX = DY = 0$.

Frame: $DX = DY = 0$.

21.2 Characteristics of the grid

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Many nodes: 134
Number and types of meshes: 96 QUAD4, 68 SEG2

22 Results of modeling J

22.1 Values tested

Identification	Reference	Type	Tolerance
Loading 1			
Normal force of contact	1,200E+04 NR	ANALYTICAL	RELATIVE – 1.00%
Tangential force of contact	0 NR	ANALYTICAL	ABSOLUTE – 5.00%
DX (not A)	1,5E-3 mm	ANALYTICAL	RELATIVE – 1.00%
DY (not A)	– 2.598E-3 mm	ANALYTICAL	RELATIVE – 1.00%
DX (not B)	1,5E-3 mm	ANALYTICAL	RELATIVE – 1.00%
DY (not B)	– 2.598E-3 mm	ANALYTICAL	RELATIVE – 1.00%
Loading 2			
Normal force of contact	1,200E+04 NR	ANALYTICAL	RELATIVE – 1.00%
Tangential force of contact	– 3,564E+03 NR	ANALYTICAL	RELATIVE – 1.00%
DX (not A)	0.0234 mm	NON_REGRESSION	RELATIVE – 1.00%
DY (not A)	0.0122 mm	NON_REGRESSION	RELATIVE – 1.00%
DX (not B)	4.032E-03 mm	NON_REGRESSION	RELATIVE – 1.00%
DY (not B)	–4,747 mm	NON_REGRESSION	RELATIVE – 1.00%
Loading 3			
Normal force of contact	1,200E+04 NR	ANALYTICAL	RELATIVE – 1.00%
Tangential force of contact	– 3,624E+03 NR	ANALYTICAL	RELATIVE – 1.00%
DX (not A)	2,598 mm	ANALYTICAL	RELATIVE – 1.00%
DY (not A)	1.5 mm	ANALYTICAL	RELATIVE – 1.00%
DX (not B)	2,598 mm	ANALYTICAL	RELATIVE – 1.00%
DY (not B)	1.5 mm	ANALYTICAL	RELATIVE – 1.00%

The analytical values for loading 1 are obtained by using the fact that the joint is elastic thanks to the parameter of penalization. It is this value which one projects in the reference mark total.

$$D_{norm} = P_{norm} / K_n = 300 / 10^5 = 3 \cdot 10^{-3} ; DX = D_{norm} \cos(\pi/6) ; DY = D_{norm} \sin(\pi/6)$$

23 Summary of the results

Whatever is modeling (2D or 3D) and the method of treatment of contact-friction, the got results are satisfactory. They are very close to the analytical results.