# SSNV505 - Contact of 2 beams in great displacements

**Summary:**

This test represents a calculation of contact without friction between two beams in great displacements subjected to a displacement specific. Initially the beams are not in contact. Once the established contact, the two beams slip one on the other.

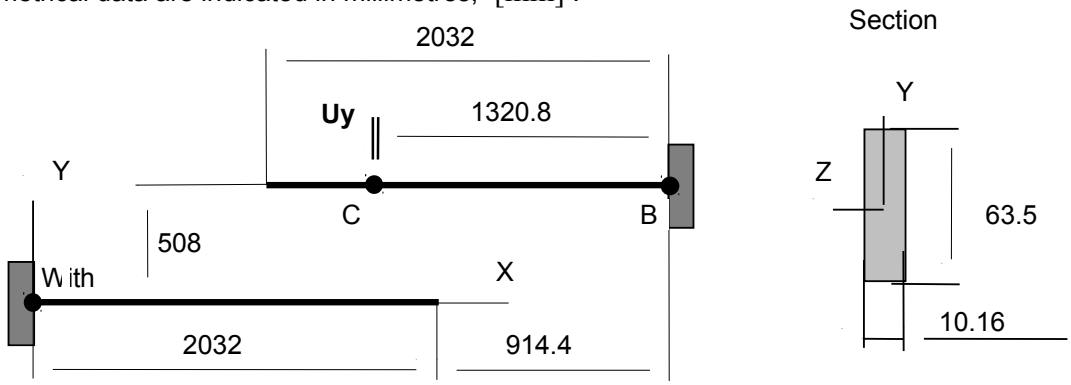
The analyzed result is the normal reaction of contact according to displacement. The results got with various modelings are compared.

- Modeling $A$ : the structure is modelled with elements of COQUE_3D associated with a mesh QUAD9, with the method CONSTRAINT.
- Modeling $B$ : the structure is modelled in $3D$ plane deformations using elements HEXA8, with the method CONSTRAINT.
- Modeling $C$ : the structure is modelled in $2D$ plane deformations using elements QUAD4, with the method CONSTRAINT.
- Modeling $D$ : the structure is modelled in $3D$ plane deformations using elements HEXA8, with the method CONTINUOUS.
- Modeling $E$ : the structure is modelled in $2D$ plane deformations using elements QUAD4, with the method CONTINUOUS.
- Modeling $F$ : the structure is modelled in $2D$ using elements of beam POU_D_E (meshs SEG2), with the methods LAGRANGIAN (with friction) and CONTINUOUS. This modeling and the following one is distinguished from the preceding ones, in what they are carried out in small transformations.
- Modeling $G$ : the structure is modelled in $2D$ using elements of beam POU_D_E (meshs SEG2), with the method LAGRANGIAN. This modeling validates the possibility of taking into account the ray of the section of beam like fictitious game.
- Modeling $H$ : the structure is modelled in $2D$ using elements of beam POU_D_TGM (meshs SEG2), with the methods LAGRANGIAN (with friction) and CONTINUOUS. This modeling is carried out in great displacements.
- Modeling $I$ : the structure is modelled in $3D$ using elements of plate DKT (meshs QUAD4), with the method CONTINUOUS . This modeling carried out in small transformations validates the good taking into account of a fictitious game for the elements of structures.

# 1 Problem of reference

## 1.1 Geometry

The geometrical data are indicated in millimetres, $[\mathrm{mm}]$ :




## 1.2 Properties of material

| | |
|---|---|
| $E=6.8948\times10^{3}\,MPa$ | Young modulus |
| $\nu=0.3333$ | Poisson's ratio |
| $\mu=0.$ | Coefficient of friction |

## 1.3 Boundary conditions and loadings

- Boundary conditions: Sections at the points $A$ and $B$ embedded
- Loading: vertical displacement of the point $C$ : $d=-790\,mm$

## 1.4 Initial conditions

Without object.

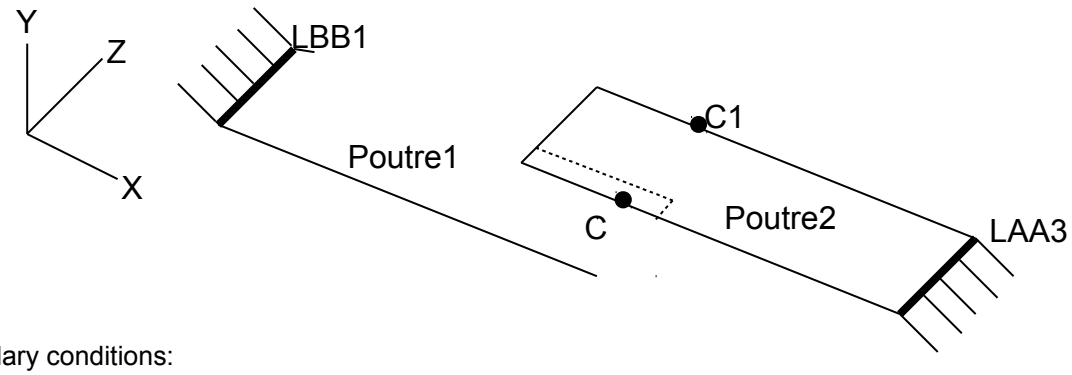
# 2 Reference solution

## 2.1 Method of calculating used for the reference solution

One does not have reference solution, one makes only tests of not-regression.

# 3 Modeling A

## 3.1 Characteristics of modeling




Boundary conditions:

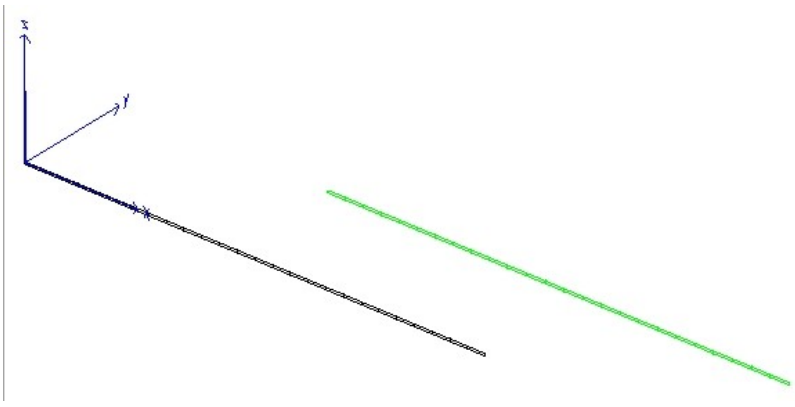
This modeling is carried out in COQUE_3D. In fact, the finite elements used are QUAD9. The boundary conditions are the following ones:

- sides $LAA3$ and $LBB1$ : $DX=DY=DZ=DRX=DRY=DRZ=0$
- Nodes tops $C$ and $C1$ : $DY=-790\,mm$
- All the nodes tops of the structure: $DZ=0$ , $DRX=0$

Conditions of contact:

- surface Master: group of meshs $POUTRE1$ less the group of meshs whose edge is embedded according to $LBB1$ ,
- surface slave: group of meshs $POUTRE2$ less the group of meshs whose edge is embedded according to $LAA3$ .

## 3.2 Characteristics of the grid



| | |
|---|---|
| Many nodes: | 261 |
| Many meshs: | 158 |
| SEG3 | 107 |
| QUAD8 | 51 |

## 3.3 Sizes tested and results

One tests the reaction to the displacement imposed on the hull. To obtain it, one calculates the reactions to embeddings in $LBB1$ and $LAA3$.

One only makes $80\%$ loading to limit the time of the CAS-test.

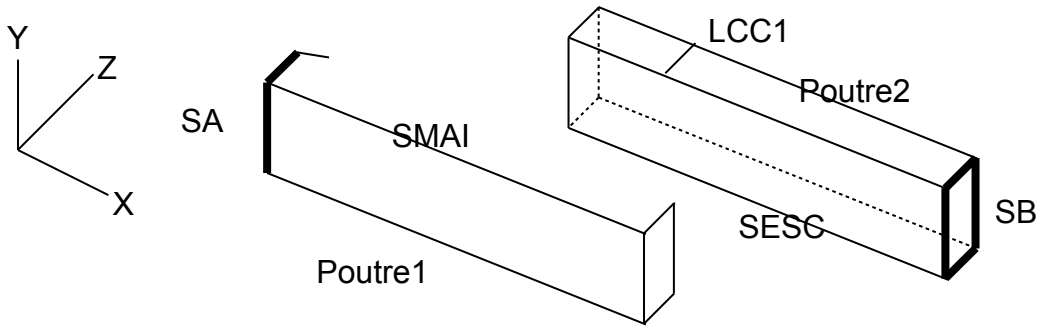
| Identification | Moments | Reference | Type of reference | Tolerance |
|---|---|---|---|---|
| Reaction | 0.2 | 313.96515859657 | 'NON_REGRESSION' | 0,10% |
| Reaction | 0.4 | 1220.6114997884 | 'NON_REGRESSION' | 0,10% |
| Reaction | 0.6 | 2456.8221137607 | 'NON_REGRESSION' | 0,10% |
| Reaction | 0.8 | 2067.7188799695 | 'NON_REGRESSION' | 0,10% |

## 3.4 Remarks

This modeling gives results very close to modeling beam (modeling $H$) but different from modelings $3D$ : it is perfectly normal because the contact is specific with the elements of structures.

# 4 Modeling B

## 4.1 Characteristics of modeling



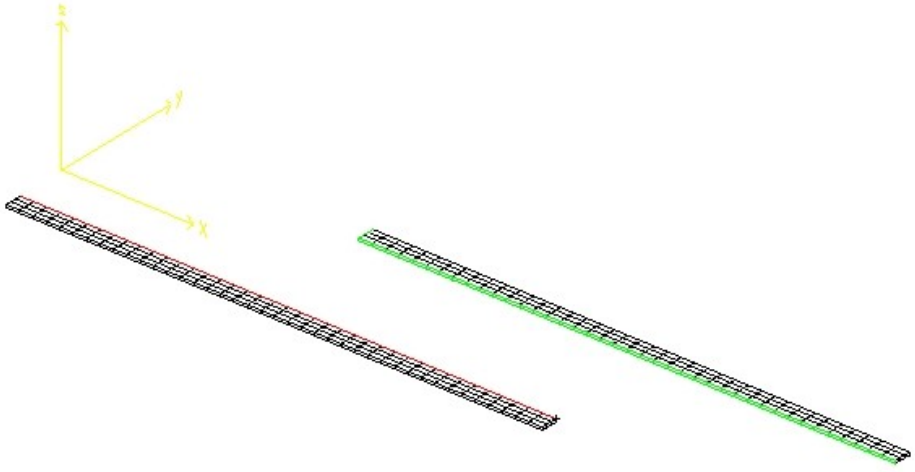

Boundary conditions:

- Surfaces $SA$ and $SB$ : $DX=DY=DZ=0$
- Lines $LCC1$ : $DY=-790\,mm$
- All the nodes tops of the structure: $DZ=0$

Conditions of contact:

- surface Master: group of meshs $SMAI$
- surface slave: group of meshs $SESC$

## 4.2 Characteristics of the grid



| | |
|---|---|
| Many nodes: | 662 |
| Many meshs: | 1247 |
| POI1 | 1 |
| SEG2 | 351 |
| QUAD4 | 655 |
| HEXA8 | 240 |

## 4.3 Sizes tested and results

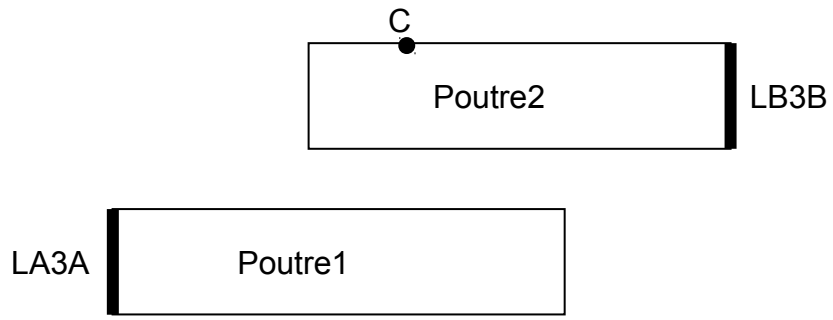
One tests the reaction to the displacement imposed on $POUTRE2$ . To obtain it, one calculates the reactions to embeddings in $SA$ and $SB$ .

| Identification | Moments | Reference | Type of reference | Tolerance |
|---|---|---|---|---|
| Reaction | 0.2 | 436,995 | 'NON_REGRESSION' | 0,10% |
| Reaction | 0.4 | 1668.34 | 'NON_REGRESSION' | 0,10% |
| Reaction | 0.6 | 3258.69 | 'NON_REGRESSION' | 0,10% |
| Reaction | 0.8 | 2737.16 | 'NON_REGRESSION' | 0.10% |
| Reaction | 1.0 | 3095.24 | 'NON_REGRESSION' | 0,10% |

# 5 Modeling C

## 5.1 Characteristics of modeling

Modeling is done in $2D$ plane deformations to find blocking in $DZ$ imposed on the model $3D$.




Boundary conditions:

- sides $LA3A$ and $LB3B$ : $DX = DY = 0$
- Nodes $C$ : $DY = -790\ mm$

Conditions of contact:

- surface Master: group of mesh $SMAI$
- surface slave: group of mesh $SESC$

## 5.2 Characteristics of the grid

| | | |
|---|---|---|
| Many meshs: | | 415 |
| | SEG2 | 175 |
| | QUAD4 | 240 |

## 5.3 Sizes tested and results

One tests the reaction to the displacement imposed on the hull. To obtain it, one calculates the reactions to embeddings in $LB3B$ and $LA3A$

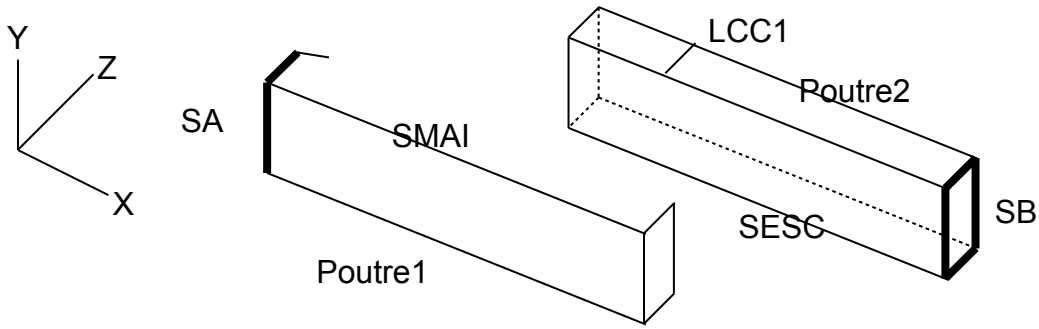
| Identification | Moments | Reference | Type of reference | Tolerance |
|---|---|---|---|---|
| Reaction | 0.2 | 43.5668 | 'NON_REGRESSION' | 0,10% |
| Reaction | 0.4 | 169,598 | 'NON_REGRESSION' | 0,10% |
| Reaction | 0.6 | 323,491 | 'NON_REGRESSION' | 0.16% |
| Reaction | 0.8 | 267,162 | 'NON_REGRESSION' | 0.10% |
| Reaction | 1.0 | 309,623 | 'NON_REGRESSION' | 0,10% |

## 5.4 Notice

To obtain in $2D$ results comparable to the results $3D$, it is necessary to multiply the preceding reactions by the width of the beam, that is to say $10.16\,mm$.

# 6 Modeling D

## 6.1 Characteristics of modeling



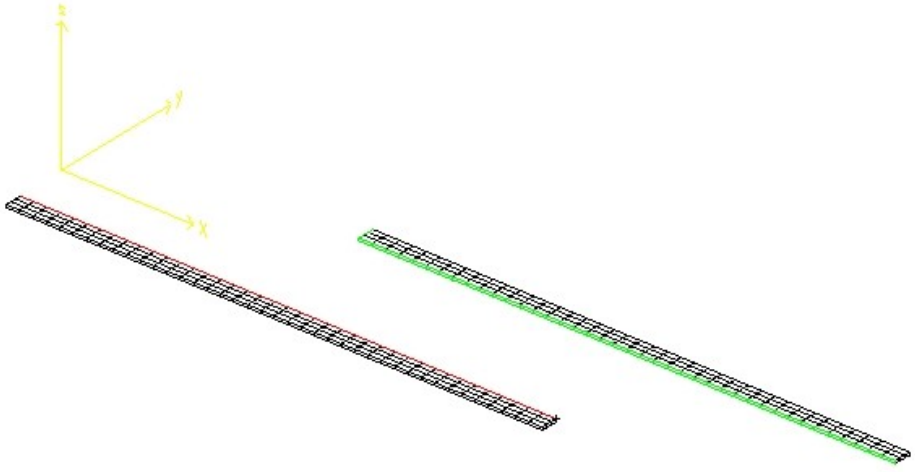

Boundary conditions:

- Surfaces $SA$ and $SB$ : $DX=DY=DZ=0$
- Line $LCC1$ : $DY=-790\ mm$
- All the nodes tops of the structure: $DZ=0$

Conditions of contact:

- surface Master: group of meshs $SMAI$
- surface slave: group of meshs $SESC$

## 6.2 Characteristics of the grid



| | |
|---|---|
| Many nodes: | 662 |
| Many meshs: | 1247 |
| POI1 | 1 |
| SEG2 | 351 |
| QUAD4 | 655 |
| HEXA8 | 240 |

## 6.3 Sizes tested and results

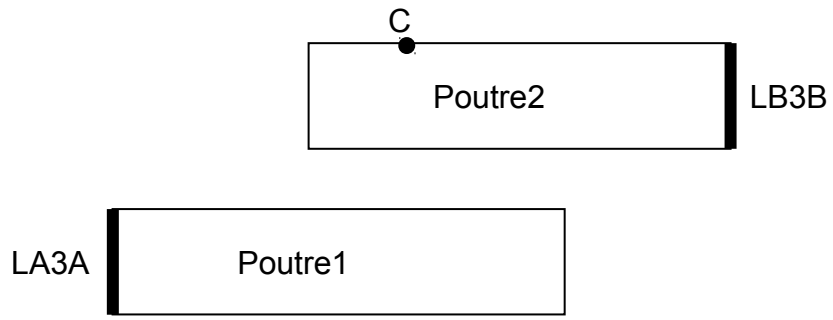
One tests the reaction to the displacement imposed on $POUTRE2$ . To obtain it, one calculates the reactions to embeddings in $SA$ and $SB$ . The percentage of difference indicates the difference between this modeling and equivalent modeling with the method CONSTRAINT.

| Identification | Moments | Reference | Type of reference | Tolerance |
|---|---|---|---|---|
| Reaction | 0.2 | 436,995 | 'NON_REGRESSION' | 0,10% |
| Reaction | 0.4 | 1668.34 | 'NON_REGRESSION' | 0,10% |
| Reaction | 0.6 | 3264.54 | 'NON_REGRESSION' | 0.15% |
| Reaction | 0.8 | 2737.16 | 'NON_REGRESSION' | 0.20% |
| Reaction | 1.0 | 3095.24 | 'NON_REGRESSION' | 0,10% |

# 7 Modeling E

## 7.1 Characteristics of modeling

Modeling is done in $2D$ plane deformations to find blocking in $DZ$ imposed on the model $3D$.




Boundary conditions:

- sides $LA3A$ and $LB3B$ : $DX = DY = 0$
- Nodes $C$ : $DY = -790\ mm$

Conditions of contact:

- surface Master: group of mesh $SMAI$
- surface slave: group of mesh $SESC$

## 7.2 Characteristics of the grid

| | | |
|---|---|---|
| Many meshs: | | 415 |
| | SEG2 | 175 |
| | QUAD4 | 240 |

## 7.3 Sizes tested and results

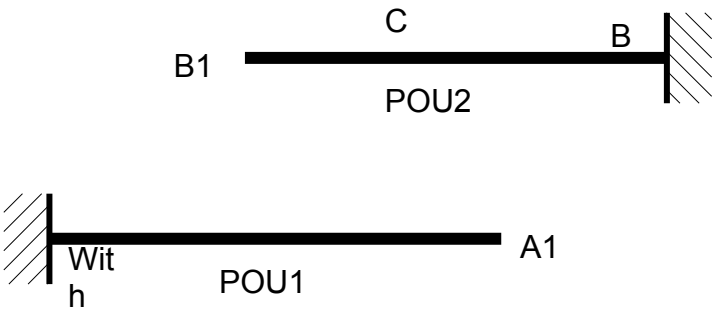
One tests the reaction to the displacement imposed on the hull. To obtain it, one calculates the reactions to embeddings in $LB3B$ and $LA3A$. The percentage of difference indicates the difference between this modeling and equivalent modeling with the method CONSTRAINT.

| Identification | Moments | Reference | Type of reference | Tolerance |
|---|---|---|---|---|
| Reaction | 0.2 | 43.5668 | 'NON_REGRESSION' | 0,10% |
| Reaction | 0.4 | 169,598 | 'NON_REGRESSION' | 0,10% |
| Reaction | 0.6 | 323,491 | 'NON_REGRESSION' | 0.16% |
| Reaction | 0.8 | 267,162 | 'NON_REGRESSION' | 0.20% |
| Reaction | 1.0 | 309,623 | 'NON_REGRESSION' | 0,10% |

# 8 Modeling F

## 8.1 Characteristics of modeling

One carries out here a modeling using elements beam in $3D$. Deformations being plane in the plan $(DX, DY)$, one imposes $DZ=0$ with the model $3D$. The goal of this CAS-test is to compare the deformation of the beams with a formulation in small rotations with that obtained with great rotations. The first model is of course abusive (forgery) compared to the second (true), but makes it possible to illustrate the difference of the results got in one or the other case. The true motivation of this CAS-test is however to display an example of validation of the contact between beams with taking into account of fictitious games.




Boundary conditions:

- Nodes $A$ and $B$ : $DX=DY=0$
- Nodes $C$ : $DY=-790\,mm$

Conditions of contact:

- surface Master: group of mesh $POU1$
- surface slave: group of mesh $POU2$

## 8.2 Characteristics of the grid

| | |
|---|---|
| Many meshs: | 80 |
| SEG2 | 80 |

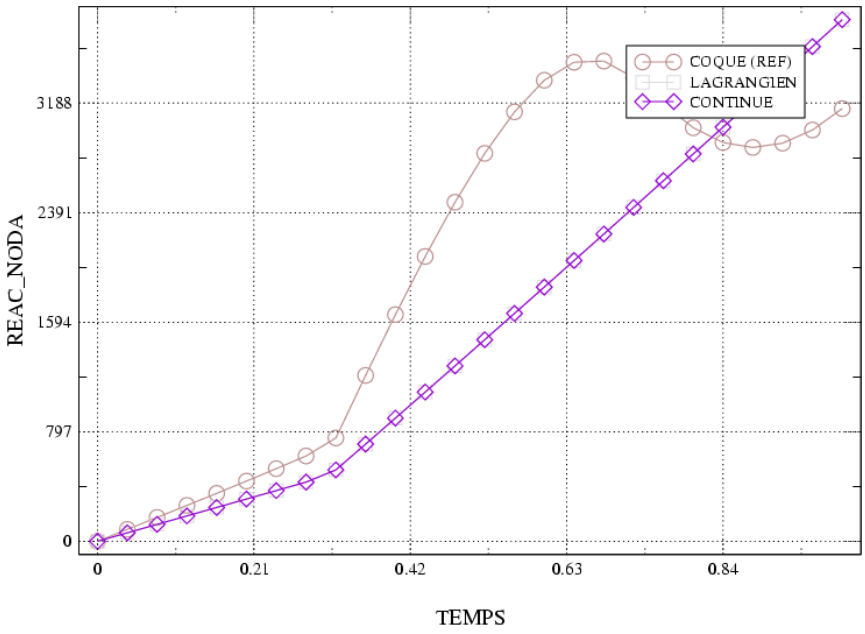
## 8.3 Sizes tested and results

One tests the reaction to the displacement imposed on the beam. To obtain it, one calculates the reactions to embeddings in $A$ and $B$. The percentage of difference indicates the difference between this modeling and equivalent modeling with the method LAGRANGIAN.

On the curve of bottom, one represented the force at the point $B$ (embedding of the higher beam) according to the evolution of the loading. One compares the methods Lagrangian and continuous with the solution obtained in great displacements. It appears that the two methods give almost identical results, but that the latter differ notably from those obtained in great displacements. This point is rather logical, since within the framework of the small disturbances in which calculations were carried out, one neglects the terms of deformation of the second order, which as one notes it are not negligible in great transformations.

| Identification | Moments | Reference | Type of reference | Tolerance |
|---|---|---|---|---|
| Reaction | 0.2 | 307.48396428348 | 'NON_REGRESSION' | 0,10% |
| Reaction | 0.4 | 1251.4883178276 | 'NON_REGRESSION' | 0,10% |
| Reaction | 0.6 | 3023.9182463545 | 'NON_REGRESSION' | 0.15% |
| Reaction | 0.8 | 4829.5740249543 | 'NON_REGRESSION' | 0.20% |
| Reaction | 1.0 | 6656.1413705692 | 'NON_REGRESSION' | 0,10% |

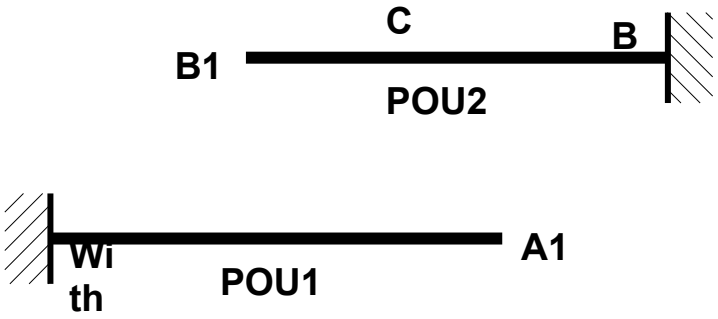
SSNV505F: NODAL REACTIONS



# 9 Modeling G

## 9.1 Characteristics of modeling

One carries out here a modeling using elements beam in $3D$. Deformations being plane in the plan $(DX, DY)$, one imposes $DZ=0$ with the model $3D$. The goal of this CAS-test is to validate the taking into account of the real section of the beam, that the user informed by the keyword 'BEAM' in AFFE_CARA_ELEM.




Boundary conditions:

- Nodes $A$ and $B$ : $DX=DY=0$
- Nodes $C$ : $DY=-790\,mm$

Conditions of contact:

- surface Master: group of mesh $POU1$
- surface slave: group of mesh $POU2$

Characteristics of the beam:

1) tubular section of ray $31.75\,mm$ and thickness $1\,mm$

## 9.2 Characteristics of the grid

| | |
|---|---|
| Many meshs: | 80 |
| SEG2 | 80 |

## 9.3 Sizes tested and results

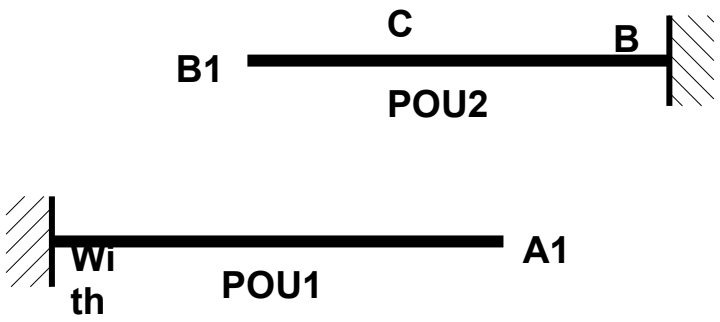
One tests the reaction to the displacement imposed on the beam. One compares the case where the section of the beam entered via a constant game DIST_ESCL and the case where one takes into account the real section via the keyword DIST_POUTRE.
Finally one also compares the formulation continues with the discrete formulation if the real section is taken into account via the keyword DIST_POUTRE.

| Identification | Moments | Reference | Type of reference | Tolerance |
|---|---|---|---|---|
| Reaction | 0.16 | 245,987 | 'AUTRE_ASTER' | 0,10% |
| Reaction | 0.4 | 1251.49 | 'AUTRE_ASTER' | 0,10% |

# 10 Modeling H

## 10.1 Characteristics of modeling

One carries out here a modeling using elements beam in $3D$. Deformations being plane in the plan $(DX, DY)$, one imposes $DZ=0$ with the model $3D$. Contrary to preceding modelings of beam, one uses here an element able to take into account great displacements (multifibre elements, [R3.08.09]).




Boundary conditions:

- Nodes $A$ and $B$ : $DX=DY=0$
- Nodes $C$ : $DY=-790\,mm$

Conditions of contact:

- surface Master: group of mesh $POU1$
- surface slave: group of mesh $POU2$

## 10.2 Characteristics of the grid

| | |
|---|---|
| Many meshs: | 80 |
| SEG2 | 80 |

## 10.3 Sizes tested and results

One tests the reaction to the displacement imposed on the beam. To obtain it, one calculates the reactions to embeddings in $A$ and $B$. Two modelings with respectively method LAGRANGIAN and method CONTINUOUS are the object of tests of not-regression.

| Identification | Moments | Reference | Type of reference | Tolerance |
|---|---|---|---|---|
| Reaction | 0.2 | 311,885 | 'NON_REGRESSION' | 0,10% |
| Reaction | 0.4 | 1208.97 | 'NON_REGRESSION' | 0,10% |
| Reaction | 0.6 | 2414.53 | 'NON_REGRESSION' | 0,10% |
| Reaction | 0.8 | 2095.62 | 'NON_REGRESSION' | 0,10% |
| Reaction | 1.0 | 2442.544 | 'NON_REGRESSION' | 0,10% |

| Identification | Moments | Reference | Type of reference | Tolerance |
|---|---|---|---|---|
| Reaction | 0.2 | 311,885 | 'NON_REGRESSION' | 0,10% |
| Reaction | 0.4 | 1210.43 | 'NON_REGRESSION' | 0,10% |
| Reaction | 0.6 | 2432.31 | 'NON_REGRESSION' | 0,10% |
| Reaction | 0.8 | 2085.15 | 'NON_REGRESSION' | 0,10% |
| Reaction | 1.0 | 2342.33 | 'NON_REGRESSION' | 0,10% |

One also tests in this modeling the use of the normal slave for the writing of the conditions of contact.

| Identification | Moments | Reference | Type of reference | Tolerance |
|---|---|---|---|---|
| Reaction | 0.2 | 311,885 | 'NON_REGRESSION' | 0,10% |
| Reaction | 0.4 | 1273.768 | 'NON_REGRESSION' | 0,10% |
| Reaction | 0.6 | 3036.885 | 'NON_REGRESSION' | 0,10% |
| Reaction | 0.8 | 4817.154 | 'NON_REGRESSION' | 0,10% |
| Reaction | 0.94 | 6256.072 | 'NON_REGRESSION' | 0,10% |

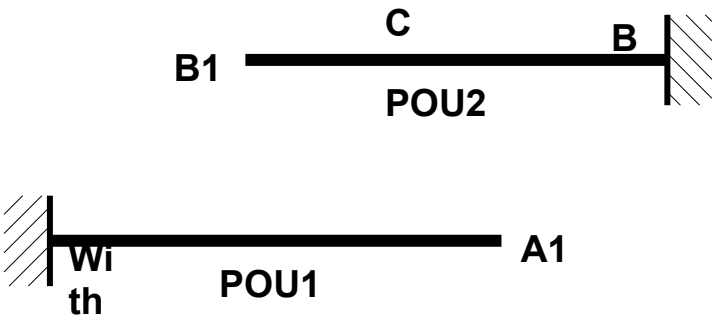
## 10.4 Remarks

One notes the very good agreement between the results got in great displacements by a model hull (modeling $A$ ) and a model beam (this modeling).
It will be noticed on the other hand that these two modelings give results different from a modeling $3D$ , that is with the description of the contact at the end of beam which is specific in modelings of structures.
One in addition notes in this modeling that certain tests are the object of not-regression: it is because the answer of the structure when the normal slave is used differs from the case where the normal Master is used (same manner as if one inverts surfaces Masters and slaves).

# 11 Modeling I

## 11.1 Characteristics of modeling

One carries out here a modeling using elements of plate in $3D$. Deformations being plane in the plan $(DX, DY)$, one imposes $DZ=0$ with the model $3D$. The goal of this CAS-test is to compare the deformation of the plates with a formulation in small rotations with that obtained with great rotations. The first model is of course abusive (forgery) compared to the second (true), but makes it possible to illustrate the difference of the results got in one or the other case. The true motivation of this CAS-test is however to display an example of validation of the contact between beams with taking into account of fictitious games.




Boundary conditions:

- Nodes $A$ and $B$ : $DX=DY=0$
- Nodes $C$ : $DY=-790\,mm$

Conditions of contact:

- surface Master: group of mesh $POU1$
- surface slave: group of mesh $POU2$

## 11.2 Characteristics of the grid

| | |
|---|---|
| Many meshs: | 90 |
| QUAD4 | 90 |

## 11.3 Sizes tested and results

One tests the reaction to the displacement imposed on the beam. To obtain it, one calculates the reactions to embeddings in $A$ and $B$. The tests are of not-regression.

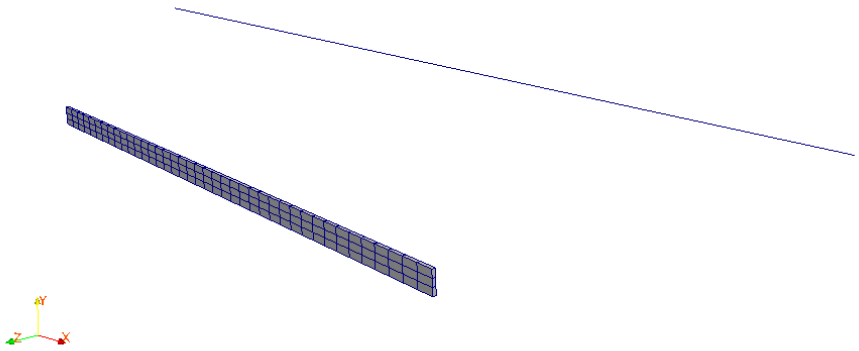
| Identification | Moments | Reference | Type of reference | Tolerance |
|---|---|---|---|---|
| Reaction | 0.2 | 345.91080450711 | 'NON_REGRESSION' | 0,10% |
| Reaction | 0.4 | 1407.8768333509 | 'NON_REGRESSION' | 0,10% |
| Reaction | 0.6 | 3401.7749540056 | 'NON_REGRESSION' | 0.10% |
| Reaction | 0.8 | 5432.9851518568 | 'NON_REGRESSION' | 0.10% |
| Reaction | 1.0 | 7487.5203886243 | 'NON_REGRESSION' | 0,10% |

It is noted first of all that the results of the model plates under Assumption of the Small Disturbances ( HPP ) are very distant from those of the models in great displacements: as explained in the conclusions of modeling $F$ (model of beam in small disturbances), it is normal.
It is noted that the results plates and beam (modeling $F$ ) differ rather largely in spite of an identical tendency. There still that can be explained by the following reason: the model plates fate of its framework of use because the thickness of the plates (of $63,5\,mm$ not modelled) is not small in particular in front in front of two other dimensions ( $10,16\,mm$ ).

# 12 Modeling J

## 12.1 Characteristics of modeling

One carries out here a modeling using elements beam and solid masses. Deformations being plane in the plan $(DX, DY)$, one imposes $DZ=0$ with the model. One uses here an element of beam able to take into account great displacements (multifibre elements, [R3.08.09]).



## 12.2 Characteristics of the grid

Many nodes: 369.
Many meshs: 40 SEG2, 120 HEXA8.

## 12.3 Sizes tested and results

One tests the reaction to the displacement imposed on the beam. To obtain it, one calculates the reactions to embeddings in $A$ and $B$. Two modelings with respectively method CONSTRAINT and method CONTINUOUS are the object of tests of not-regression. Moreover modeling CONTINUOUS is compared with modeling CONSTRAINT.

The first calculation (method CONSTRAINT)

| Identification | Moments | Reference | Type of reference | Tolerance |
|---|---|---|---|---|
| Reaction | 0.2 | 311.88 | 'NON_REGRESSION' | 0,10% |
| Reaction | 0.4 | 1498.48 | 'NON_REGRESSION' | 0,10% |
| Reaction | 0.6 | 3042.17 | 'NON_REGRESSION' | 0,10% |
| Reaction | 0.8 | 2172 | 'NON_REGRESSION' | 0,10% |
| Reaction | 1.0 | 2159.73 | 'NON_REGRESSION' | 0,10% |

The second calculation (formulation CONTINUOUS)

| Identification | Moments | Reference | Type of reference | Tolerance |
|---|---|---|---|---|
| Reaction | 0.2 | 311.88 | 'AUTRE_ASTER' | 0,10% |
| Reaction | 0.4 | 1498.48 | 'AUTRE_ASTER' | 0,10% |
| Reaction | 0.6 | 3042.17 | 'AUTRE_ASTER' | 0,10% |
| Reaction | 0.8 | 2172 | 'AUTRE_ASTER' | 1.0% |
| Reaction | 1.0 | 2159.73 | 'AUTRE_ASTER' | 2.0% |

| Identification | Moments | Reference | Type of reference | Tolerance |
|---|---|---|---|---|
| Reaction | 0.2 | 311.88 | 'NON_REGRESSION' | 0,10% |
| Reaction | 0.4 | 1498.49 | 'NON_REGRESSION' | 0,10% |
| Reaction | 0.6 | 3042.27 | 'NON_REGRESSION' | 0,10% |
| Reaction | 0.8 | 2191.47 | 'NON_REGRESSION' | 0,10% |
| Reaction | 0.94 | 2183.24 | 'NON_REGRESSION' | 0,10% |

## 12.4 Remarks

The results got between the two formulations of contact are close although they differ from a few percent at the end of the loading: these differences can be explained by the modeling of beam used (POU_D_TGM in great displacements) which is sensitive to the iteration count of Newton (approximate formulation of great displacements). A refinement of the step of time must correct this variation.
This modeling validates the contact between an edge and a facet for the two formulations of contact.

It is noted that the got results are different from the contact beam-beam and contact 3D-3D. The particular geometrical configuration of this test explains that (the zone of contact is different in each case).

# 13 Summary of the results

The graph below presents the evolution of the component $DY$ force of reaction to the displacement imposed according to this last.
One notices very a good agreement between various modelings until $500\,mm$ then the curve COQUE_3D (just as modeling POU_D_TGM) separates from $2D$ and of $3D$ before meeting with $700\,mm$ . This variation is normal: it appears when the end of beam 2 is orthogonal with beam 1 (specific description of the contact *vs.* description $3D$ ).