SDNL140 – Damped vibration of two beams while contact-rubbing

Summary:

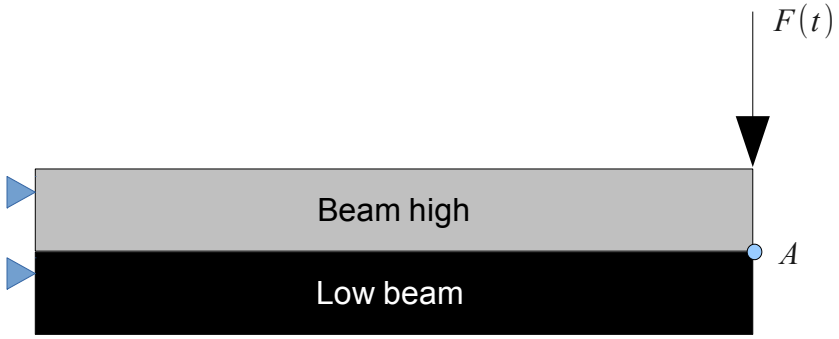
This test models the nonlinear vibratory answer of two beams while contact-rubbing, subjected to the effect of a force concentrated with one of the ends of the beam. The ultimate goal is to validate the order DYNA_NON_LINE with a linear elastic behavior and contact-friction with DEFI_CONTACT. The reference solution is not analytical but resulting from a calculation finite elements with a method of penalization for the contact and an explicit diagram.

Modelings suggested depend on the diagrams of differences finished in time and on the space discretization.

- **Modelings** A : linear grid with TETRA4 and diagram of HHT (implicit). In this modeling, one tests the reference solution like one SOURCE_EXTERNE with an algorithm of generalized Newton. One tests also various algorithms of Code_Aster (POINT_FIXE, PARTIAL NEWTON, GCP, PENALISEE) as solutions AUTRE_ASTER.
- **Modelings** B : quadratic grid with TETRA10 and diagram of HHT (implicit). One tests the algorithms of Code_Aster generalized Newton, partial Newton as solutions AUTRE_ASTER.
- **Modelings** C : linear grid with HEXA8 and diagram of HHT (implicit). One tests the algorithms of Code_Aster generalized Newton, partial Newton as solutions AUTRE_ASTER.
- **Modelings** D : quadratic grid HEXA27 and diagram of HHT (implicit). One tests the algorithms of Code_Aster generalized Newton, partial Newton as solutions AUTRE_ASTER.
- **Modelings** E : linear grid HEXA8 and diagram of NEWMARK (implicit). One tests the algorithms of Code_Aster generalized Newton, partial Newton as solutions AUTRE_ASTER.
- **Modelings** F : linear grid with QUAD4 and diagram of HHT (implicit). One tests the algorithms of Code_Aster generalized Newton, partial Newton as solutions AUTRE_ASTER.

1 Problem of reference

1.1 Geometry



coordinates points are given in meters (m):

Length	1
Height	0.1

1.2 Material properties

The material has an isotropic elastic behavior:

Young modulus	200GPa
Poisson's ratio	0.0
Density	7800kg/m^3
Coefficient of friction	0.2

1.3 Boundary conditions and loadings

Initially, the two beams at rest and are not deformed. The dynamic evolution of the two structures is such as: in $X=0$, the two beams are embedded and in $X=L$, the beam of bottom is free while the beam top is subjected to an impulse of " *Heaviside "(*Constant force concentrated in time).

Two surfaces are initially in contact. Moreover, one made the choice to make initially these two surfaces of contact compatible.

2 Reference solution

2.1 Method of calculating used for the reference solution

The reference solution is drawn from [bib1]. It is about a calculation finite elements with a method of penalization and a diagram in explicit time of centered difference. The grid as well as the result of the calculation of reference are presented below.

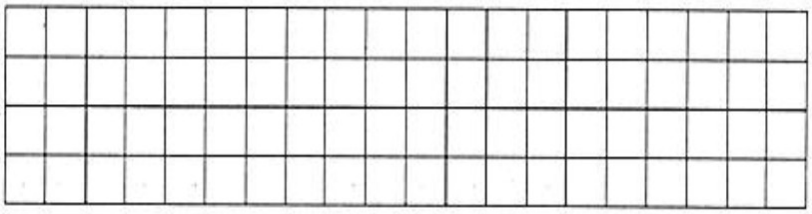


Figure: Grid finite element of the calculation of reference (Extracted from [bib1]).

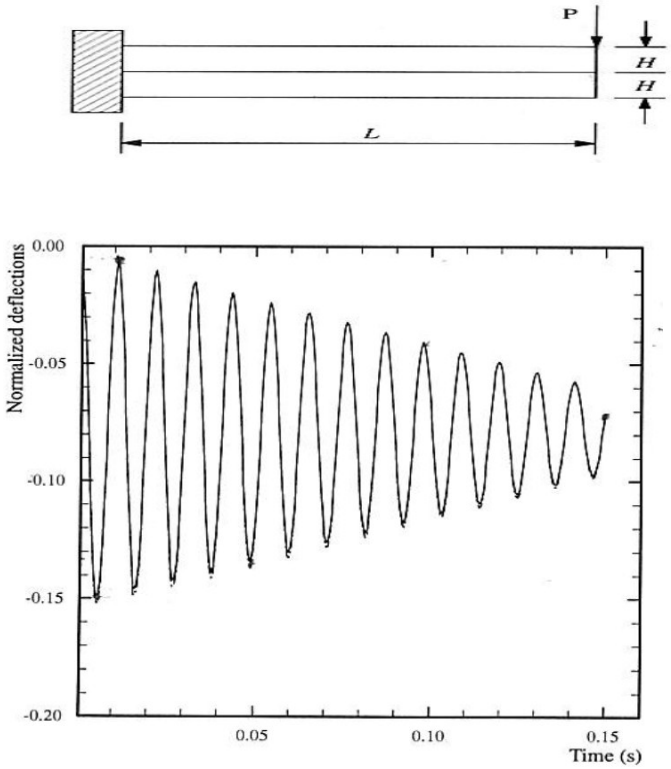


Figure: Solution in vertical displacement of the calculation of reference (Extracted from [bib1]).

It is seen well that the solution is deadened in time. Damping is strongly related to the parameters of connections (impact, friction, reactions to the supports)

2.2 Uncertainty on the solution

All the digital parameters of the reference solution not being known, one can expect differences between the solution SOURCE_EXTERNE and the solution of the code. One will be interested rather in the orders of magnitude.

In certain modelings, one seeks to compare the results of various algorithms and diagrams. With this intention, one does the same calculation with DYNA_NON_LINE by changing only the definition of the contact following the algorithm or the definition of the diagram into time. Then one creates, from CREA_CHAMP, a structure of the type EVOL_NOLI representing the difference in results between two algorithms/diagrams. Lastly, one tests if the results of the two algorithms/diagrams are the same ones in a node.

2.3 Bibliographical references

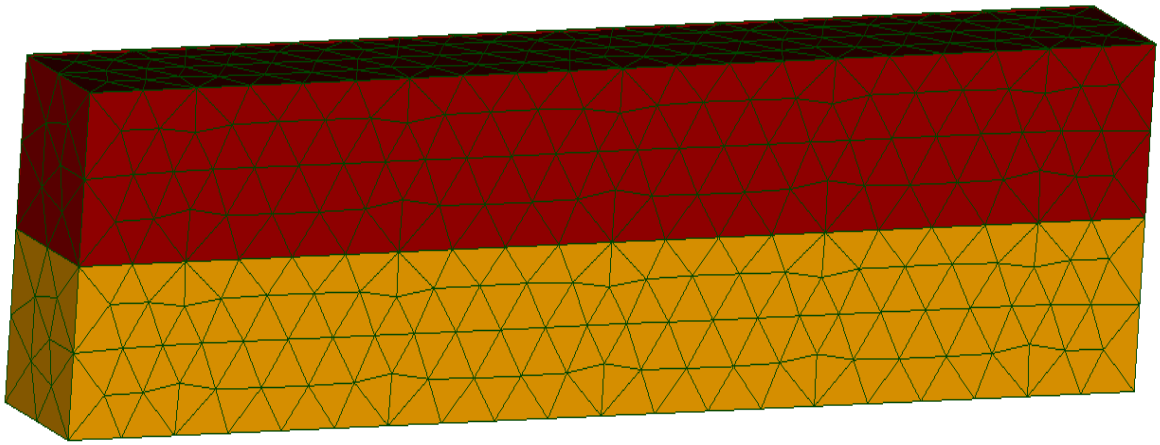
[1] Zhi-hooted Zong, Finite element procedures for Contact-Impact problems, Oxford Science Publication, p162.

3 Modeling A

3.1 Characteristics of modeling

- Modeling 3D
- Relation of elastic behavior linear.

3.2 Characteristics of the grid



- Many nodes 1051
- Many nodes slaves 118
- Many meshs
  - TETRA4 3535
  - TRIA3 1584
  - Slave and Master 190*2
- Groups of nodes:
  - Clim_Bas
- Groups of meshs:
  - High
  - Bas_Encastre
  - Bas_Contact
  - Bas_Libre
  - Low
  - Haut_Pression
  - Haut_Contact
  - Haut_Encastre
  - Haut_Libre

3.3 Characteristics of the fields tested

- Formulation continues = STANDARD

```
Evol1 = DYNA_NON_LINE+NEWTON_GENERALISE+HHT (ALPHA=-0.3 and MODI_EQUI='
OUI')
Evol2 = DYNA_NON_LINE+NEWTON_PARTIEL +HHT (ALPHA=-0.3 and MODI_EQUI='
OUI')
```

- Formulation continues = PENALIZE

```
Evol3 = DYNA_NON_LINE+NEWTON_PARTIEL +HHT (ALPHA=-0.3 and MODI_EQUI='
OUI')
Evol4 = DYNA_NON_LINE+POINT_FIXE +HHT (ALPHA=-0.3 and MODI_EQUI='
OUI')
```

- Discrete formulation

```
Evol5 = DYNA_NON_LINE+LAGRANGIEN+PENALISATION+HHT
              (ALPHA=-0.3 and MODI_EQUI=' OUI')


Evol12 =  Evol1-Evol2
Evol13 =  Evol1-Evol3
Evol14 =  Evol1-Evol4
Evol15 =  Evol1-Evol5
```

For questions of performances, reliability and robustness the step of time is selected to 0,001:
- One tests `evol1` with 'SOURCE_EXTERNE' at moments 0,006 and 0,012.
- The solutions are tested `Evol12` with `Evol15` who are 'AUTRE_ASTER'at moment 0.001.

3.4 Sizes tested and results

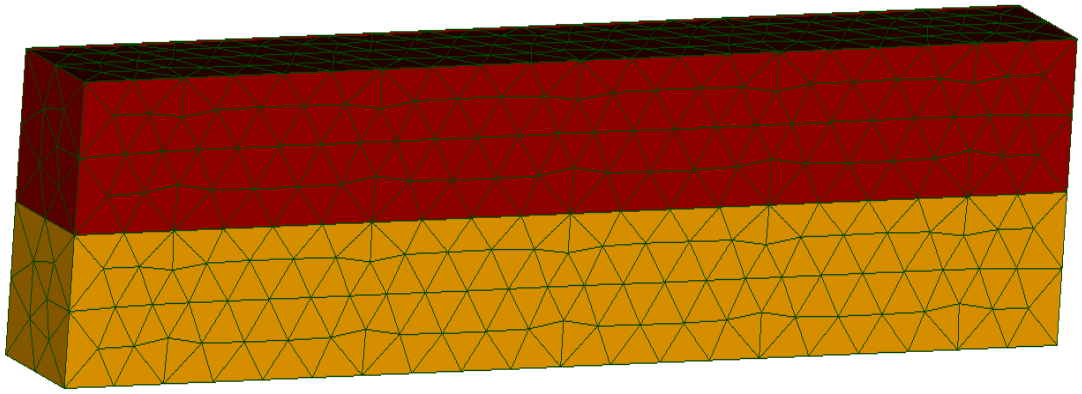
Identification	Moment (S)	Type of reference	Value of reference	Tolerance (%)
DY (Evol1)	0.006	'SOURCE_EXTERNE'	-0.15	10.0
DY (Evol1)	0.012	'SOURCE_EXTERNE'	-0.009	0.1
DY (Evol12)	0.001	'AUTRE_ASTER'	0.0	0.1
DY (Evol13)	0.001	'AUTRE_ASTER'	0.0	0.1
DY (Evol14)	0.001	'AUTRE_ASTER'	0.0	0.1
DY (Evol15)	0.001	'AUTRE_ASTER'	0.0	0.1

4 Modeling B

4.1 Characteristics of modeling

- Modeling 3D
- Elastic relation of behavior linear.

4.2 Characteristics of the grid



- Many nodes 6,427
- Many nodes slaves 199
- Many meshs
  - TETRA10 3,535
  - TRIA6 1,584
  - Slave and Master 190*2
- Groups of nodes:
  - Clim_Bas
- Groups of meshs:
  - High
  - Bas_Encastre
  - Bas_Contact
  - Bas_Libre
  - Low
  - Haut_Pression
  - Haut_Contact
  - Haut_Encastre
  - Haut_Libre

4.3 Characteristics of the fields tested

- Formulation continues = STANDARD

```
Evol1 = DYNA_NON_LINE+NEWTON_GENERALISE+HHT (ALPHA=-0.3 and MODI_EQUI='
OUI')
Evol2 = DYNA_NON_LINE+NEWTON_PARTIEL   +HHT (ALPHA=-0.3 and MODI_EQUI='
OUI')
```

For questions of performances, reliability and robustness the step of time is selected to 0,001. The solution is tested Evol12=Evol1-Evol2 who is 'AUTRE_ASTER'at moment 0.001.

4.4 Sizes tested and results

Identification	Moment (S)	Type of reference	Value of reference	Tolerance

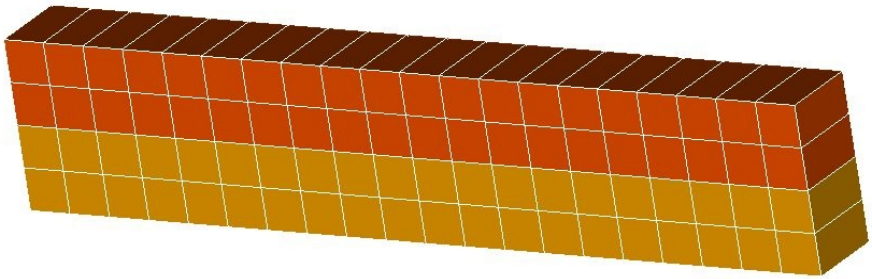
				(%)
DY (Evol12)	0.001	'AUTRE_ASTER'	0.0	0.1

5 Modeling C

5.1 Characteristics of modeling

- Modeling 3D
- Elastic relation of behavior linear.

5.2 Characteristics of the grid



- Many nodes 252
- Many nodes slaves 42
- Many meshs
  - HEXA8 80
  - QUAD4 248
  - Slave and Master 20* *2
- Groups of meshs:
  - Bas_Encastre
  - Bas_Contact
  - Clim_Bas
  - Haut_Pression
  - Haut_Contact
  - Haut_Encastre

5.3 Characteristics of the fields tested

- Formulation continues = STANDARD

```
Evol1 = DYNA_NON_LINE+NEWTON_GENERALISE+HHT (ALPHA=-0.3 and MODI_EQUI='
OUI')
Evol2 = DYNA_NON_LINE+NEWTON_PARTIEL   +HHT (ALPHA=-0.3 and MODI_EQUI='
OUI')
```

For questions of performances, reliability and robustness the step of time is selected to 0,001. L is tested has solution E vol12 = Evol1-Evol2 who be T ' AUTRE_ASTER 'at moment 0.00 1 .

5.4 Sizes tested and results

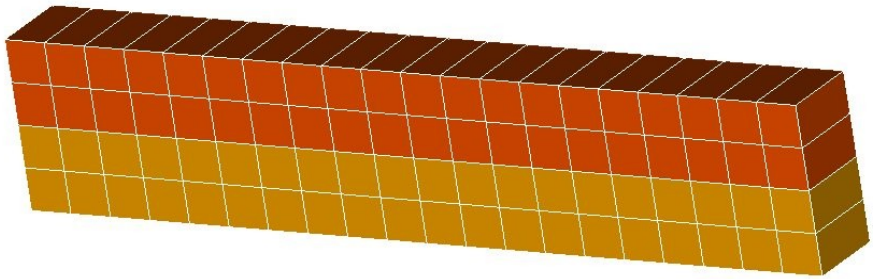
Identification	Moment (S)	Type of reference	Value of reference	Tolerance (%)
DY (Evol12)	0.001	'AUTRE_ASTER'	0.0	0.1

6 Modeling D

6.1 Characteristics of modeling

- Modeling 3D
- Elastic relation of behavior linear.

6.2 Characteristics of the grid



- Many nodes 786
- Many nodes slaves 82
- Many meshs
  - HEXA20 80
  - QUAD8 248
  - Slave and Master 20* *2
- Groups of meshs:
  - Bas_Encastre
  - Bas_Contact
  - Clim_Bas
  - Haut_Pression
  - Haut_Contact
  - Haut_Encastre
  -

6.3 Characteristics of the fields tested

- Formulation continues = STANDARD

```
Evol1 = DYNA_NON_LINE+NEWTON_GENERALISE+HHT (ALPHA=-0.3 and MODI_EQUI='
OUI')
Evol2 = DYNA_NON_LINE+NEWTON_PARTIEL   +HHT (ALPHA=-0.3 and MODI_EQUI='
OUI')
```

For questions of performances, reliability and robustness the step of time is selected to 0,001. The solution is tested Evol12=Evol1-Evol2 who is 'AUTRE_ASTER'at moment 0.001.

6.4 Sizes tested and results

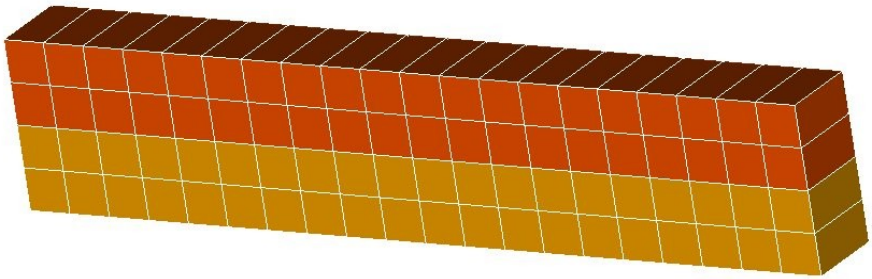
Identification	Moment (S)	Type of reference	Value of reference	Tolerance (%)
DY (Evol12)	0.001	'AUTRE_ASTER'	0.0	0.1

7 Modeling E

7.1 Characteristics of modeling

- Modeling 3D
- Elastic relation of behavior linear.

7.2 Characteristics of the grid



- Many nodes 252
- Many nodes slaves 42
- Many meshs
  - HEXA8 80
  - QUAD4 248
  - Slave and Master 20* *2
- Groups of meshs:
  - Bas_Encastre
  - Bas_Contact
  - Clim_Bas
  - Haut_Pression
  - Haut_Contact
  - Haut_Encastre

7.3 Characteristics of the fields tested

- Formulation continues = STANDARD

```
Evol1 = DYNA_NON_LINE+NEWTON_GENERALISE+HHT (ALPHA=-0.3 and MODI_EQUI='
OUI')
Evol2 = DYNA_NON_LINE+NEWTON_PARTIEL   +HHT (ALPHA=-0.3 and MODI_EQUI='
OUI')
```

For questions of performances, reliability and robustness the step of time is selected to 0,001. The solution is tested Evol12=Evol1-Evol2 who is 'AUTRE_ASTER'at moment 0.001.

7.4 Sizes tested and results

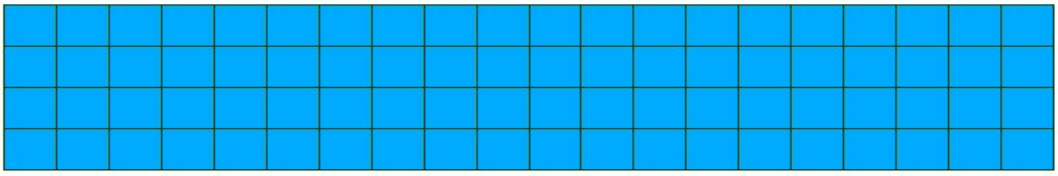
Identification	Moment (S)	Type of reference	Value of reference	Tolerance (%)
DY (Evol12)	0.001	'AUTRE_ASTER'	0.0	0.1

8 Modeling F

8.1 Characteristics of modeling

- Modeling 2D
- Elastic relation of behavior linear.

8.2 Characteristics of the grid



- Many nodes 126
- Many nodes slaves 21
- Many meshs
  - QUAD4 88
  - SEG2 80
  - Slave and Master 21*2
- Groups of nodes:
  - Force
- Groups of meshs:
  - Low
  - Beam
  - High
  - Embedding
  - Bord_Libre
  - Bas_Contact
  - Haut_Contact

8.3 Characteristics of the fields tested

- Formulation continues = STANDARD

```
Evol1 = DYNA_NON_LINE+NEWTON_GENERALISE+HHT (ALPHA=-0.3 and MODI_EQUI='
OUI')
Evol2 = DYNA_NON_LINE+NEWTON_PARTIEL   +HHT (ALPHA=-0.3 and MODI_EQUI='
OUI')
```

For questions of performances, reliability and robustness the step of time is selected to 0,001. The solution is tested Evol12=Evol1-Evol2 who is 'AUTRE_ASTER'at moment 0.001.

8.4 Sizes tested and results

Identification	Moment (S)	Type of reference	Value of reference	Tolerance (%)
DY (Evol12)	0.001	'AUTRE_ASTER'	0.0	0.1

9 Summaries of the results

The results are in agreement with the reference solution.

In addition, concerning the implicit methods, it is necessary to choose the step of time of kind to be able to get at the same time right and convergent results. In practice this choice must be to bind to the respect of the condition of Current-Friedrichs-Levy.