

SDND124 – seismic Excitation of discrete affected of behavior DIS_ECRO_TRAC

Summary:

One tests the answer of the nonlinear model of behavior DIS_ECRO_TRAC, formulated on discrete elements for meshes SEG2 .

Operators DYNA_NON_LINE and DYNA_VIBRA are employed for the validation. One analyzes the answer of discrete elements supporting a nonlinear law of behavior under a seismic loading.

Modelings and discrete elements tested are in 3D with modeling DIS_T on a mesh SEG2.

This behavior is also validated for not-dynamic requests in the CAS-test SSND117 [V6.08.117] with the operator STAT_NON_LINE.

1 Problem of reference

1.1 Description of the device

The studied system is represented by the rheological model below. It is composed of an affected non-linear element of the behavior `DIS_ECRO_TRAC` (between the nodes `N1` and `N2`), of a mass assigned to the node `N2`, of a linear element (between the nodes `N2` and `N3`).

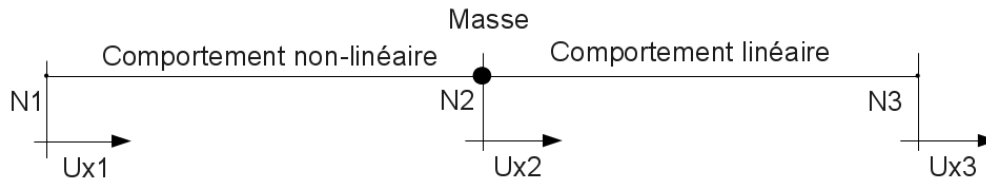


Figure 1.1-a : Model of the device.

The equations governing the behavior of the non-linear element are in [R5.03.17].

1.2 Modelings

Modelings tested are on elements `DIS_T`, meshes `SEG2`. The characteristics of the discrete elements are of the type: `K_T_D_L`.

Note: The units of the parameters must be in agreement with the unit of the efforts, the unit lengths [R5.03.17]. For all modelings the units are homogeneous with [NR], [mm].

Note: Modelings A and B treats the same system, with the same boundary conditions, the same loading.

1.2.1 Modeling A

This modeling makes it possible to test the nonlinear behavior of the law `DIS_ECRO_TRAC` with the operator `DYNA_NON_LINE`.

1.2.2 Modeling B

This modeling makes it possible to test the nonlinear behavior of the law `DIS_ECRO_TRAC` with the operator `DYNA_VIBRA`.

1.3 Properties materials

1.3.1 Modeling A and B

The stiffness of the linear device is $k_{lin} = 400 \text{ N/mm}$.

The mass is $M = 200 \text{ kg}$.

The non-linear behavior used in the case test is presented to the figure 1.3.1-a :

- Elastic behavior up to the point $(0.5 \text{ mm}, 200.0 \text{ N})$.
- Non-linear behavior, governs by the following equation:

$$R(p) = \frac{K_{elas} \cdot p}{\left[1 + \left(\frac{k_{elas} \cdot p}{F_u - F_y} \right)^n \right]^{1/n}}$$

with

$$K_{elas} = \frac{200.0 \text{ N}}{0.5 \text{ mm}} = 400 \text{ N/mm}$$

$$F_y = 200.0 \text{ N}$$

$$F_u = 450.0 \text{ N}$$

$$n = 1.5$$

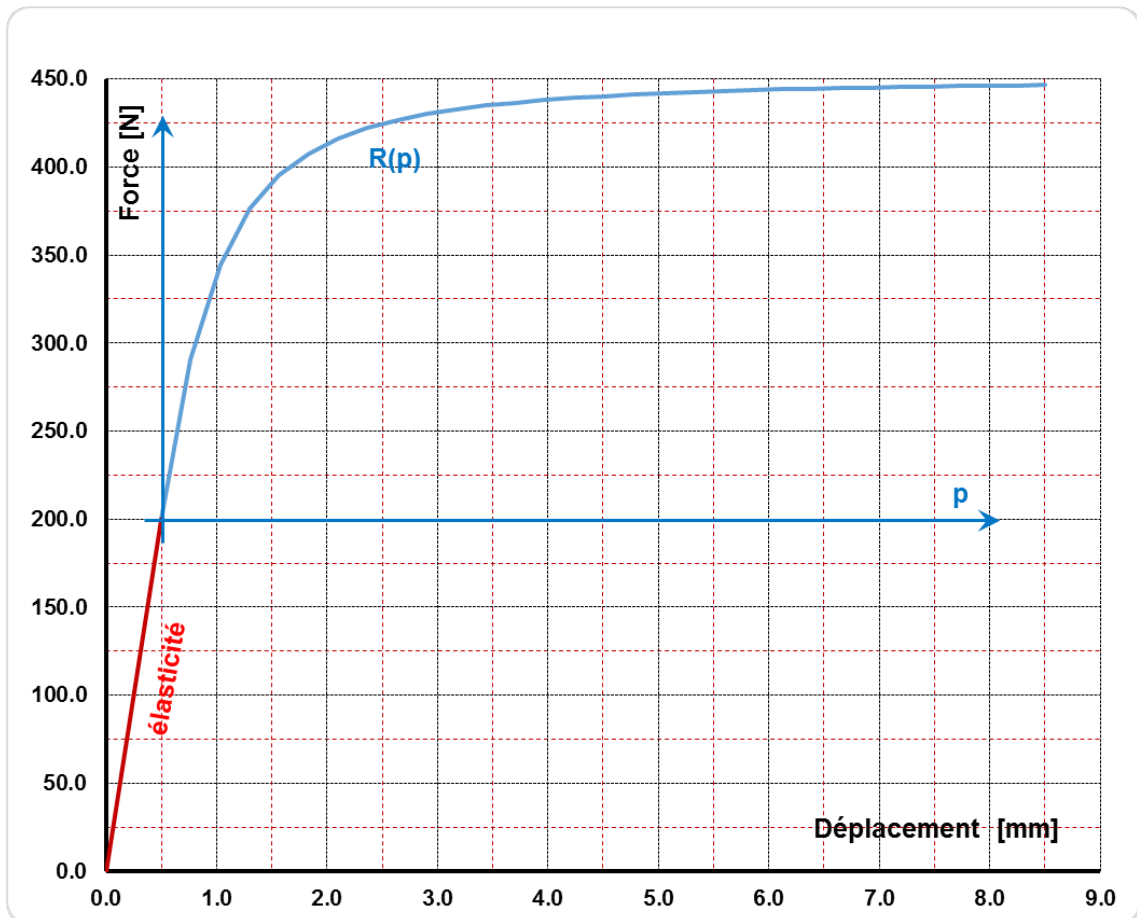


Figure 1.3.1-a : Non-linear behavior

1.4 Boundary conditions and loadings

Nodes N1, N2, N3 are blocked in the directions Y and Z.

For modeling A, nodes N1 and N3 are subjected to displacement $U(t)$ in the direction X.

For modeling B, the nodes N1 and N3 are subjected to displacement $U(t)$, speed $V(t)$ and acceleration $\gamma(t)$ in the direction X.

The condition in function displacement of time:

$$U(t) = U_0 \cdot \sin(2\pi \cdot f \cdot t) / (2\pi \cdot f) \quad \text{with } f = 0.5 \text{ Hz} \quad \text{and } U_0 = 6.0 \text{ mm}$$

The condition of speed function of time: $V(t) = \dot{U}(t)$

The condition in acceleration function of time: $\gamma(t) = \ddot{U}(t)$

2 Reference solutions

2.1 Method of calculating used for the reference solutions

2.1.1 Modeling A

Modeling *A* the reference solution for modeling is useful *B* .

2.1.2 Modeling B

The reference solution is that resulting from modeling *A* .

2.2 Uncertainty on the solution

2.2.1 Modeling A

Without object.

2.2.2 Modeling B

Without object.

3 Modeling A

3.1 Characteristics of modeling

Modelings tested are DIS_T on meshes SEG2. The characteristics of stiffness of discrete are thus of the type: K_T_D_L, M_T_D_N.

3.2 Characteristics of the grid

Many nodes: 3, many meshes: 2, elements SEG2 : 2, elements POI1 : 1.

3.3 Boundary conditions and loadings

Nodes N1, N2, N3 are blocked in the directions Y and Z.

Nodes N1 and N3 are subjected to displacement $U(t)$ in the direction X.

$$U(t) = U_0 \cdot \sin(2\pi \cdot f \cdot t) / (2\pi \cdot f) \text{ with } f = 0.5 \text{ Hz and } U_0 = 6.0 \text{ mm}$$

3.4 Sizes tested and results

The sizes are tested in not-regression, with the tolerances by default:

- the displacement of the node N2,
- effort with the node N2,
- power dissipated in the non-linear device,
- the unelastic displacement of the non-linear device,
- unelastic displacement cumulated of the non-linear device.

The moments appointed to test the various sizes are those where the effort reached a extrema.

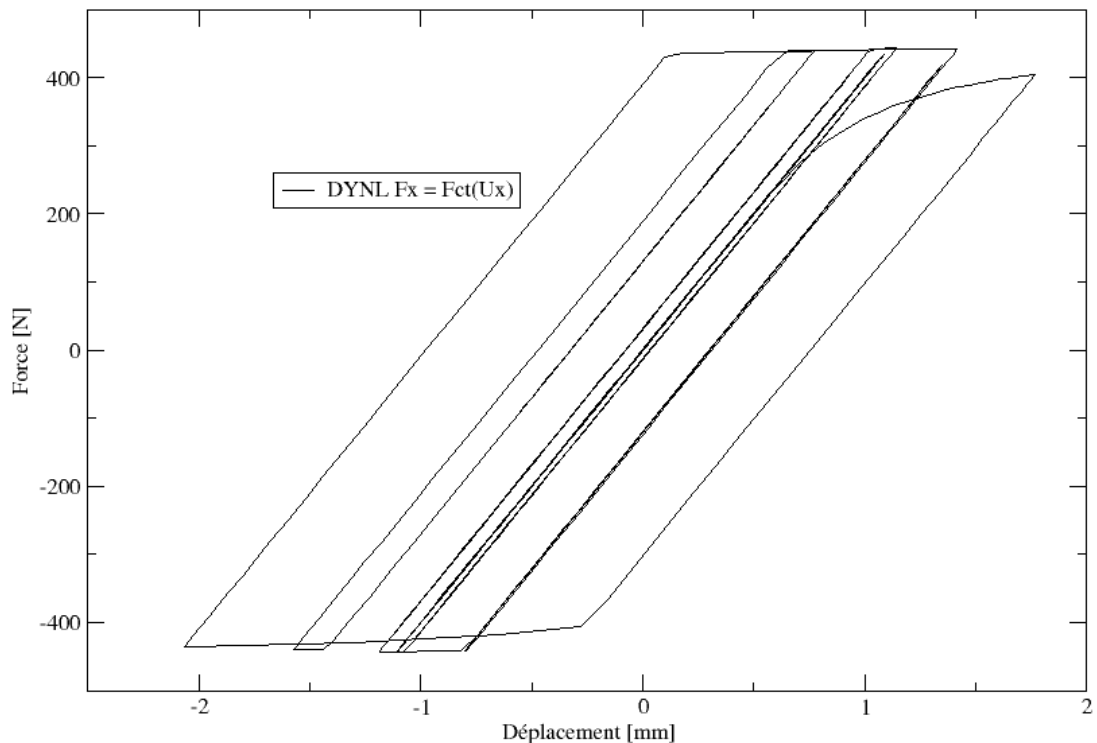


Figure 3.4-a : Answer force-displacement to the node N2 .

The following table gives the values of the internal variables related to the behavior DIS_ECRO_TRAC, at the moments when the force reaches a extrema.

INST	Force	Ux	Power	Up	p
1,275	4,0514895E+02	1,7698260E+00	2,7736499E+02	7,5695300E-01	1,2698160E+00
2,525	-4,3584585E+02	-2,0647460E+00	1,0140956E+03	-9,7513100E-01	3,0786590E+00
3,625	4,3921743E+02	7,7222800E-01	1,2982852E+03	-3,2581600E-01	3,7364570E+00
4,525	-9,1517870E+01	-5,5460400E-01	1,2982881E+03	-3,2580900E-01	3,7364630E+00
5,375	3,5606066E+02	5,6434300E-01	1,2982881E+03	-3,2580900E-01	3,7364630E+00
6,400	-4,3979664E+02	-1,5724580E+00	1,3629654E+03	-4,7296700E-01	3,8850760E+00
7,525	4,4218454E+02	1,4184290E+00	1,7096346E+03	3,1296800E-01	4,6769870E+00
8,550	-4,4221218E+02	-8,0345000E-01	1,7144548E+03	3,0208000E-01	4,6879540E+00
9,500	2,2752558E+02	8,7087900E-01	1,7144615E+03	3,0206500E-01	4,6879690E+00
10,450	-4,0783182E+02	-7,1751500E-01	1,7144615E+03	3,0206500E-01	4,6879690E+00
11,450	4,1833666E+02	1,3479060E+00	1,7144615E+03	3,0206500E-01	4,6879690E+00
12,525	-4,4304092E+02	-1,1860040E+00	1,8828698E+03	-7,8402000E-02	5,0705250E+00
13,525	4,0986344E+02	9,4625300E-01	1,8828717E+03	-7,8406000E-02	5,0705290E+00
14,500	-3,2997442E+02	-9,0334200E-01	1,8828717E+03	-7,8406000E-02	5,0705290E+00
15,475	3,8962561E+02	8,9565800E-01	1,8828717E+03	-7,8406000E-02	5,0705290E+00
16,475	-4,2729911E+02	-1,1466540E+00	1,8828717E+03	-7,8406000E-02	5,0705290E+00
17,500	4,4325666E+02	1,1421040E+00	1,9326673E+03	3,3962000E-02	5,1834430E+00
18,525	-4,2314598E+02	-1,0239020E+00	1,9326676E+03	3,3963000E-02	5,1834440E+00
19,500	3,6609776E+02	9,4920700E-01	1,9326676E+03	3,3963000E-02	5,1834440E+00
20,500	-3,7879652E+02	-9,1302900E-01	1,9326676E+03	3,3963000E-02	5,1834440E+00
21,475	4,0795131E+02	1,0538410E+00	1,9326676E+03	3,3963000E-02	5,1834440E+00
22,500	-4,4331859E+02	-1,1071190E+00	1,9472008E+03	1,1780000E-03	5,2163830E+00
23,525	4,3377501E+02	1,0856150E+00	1,9472010E+03	1,1770000E-03	5,2163840E+00
24,525	-3,9592010E+02	-9,8862300E-01	1,9472010E+03	1,1770000E-03	5,2163840E+00
25,500	3,7185745E+02	9,3082100E-01	1,9472010E+03	1,1770000E-03	5,2163840E+00
26,475	-3,9223062E+02	-9,7939900E-01	1,9472010E+03	1,1770000E-03	5,2163840E+00
27,475	4,3090550E+02	1,0784410E+00	1,9472010E+03	1,1770000E-03	5,2163840E+00
28,500	-4,4332341E+02	-1,1099060E+00	1,9484309E+03	-1,5970000E-03	5,2191710E+00
29,525	4,1639039E+02	1,0393790E+00	1,9484309E+03	-1,5970000E-03	5,2191710E+00
30,500	-3,7903620E+02	-9,4918800E-01	1,9484309E+03	-1,5970000E-03	5,2191710E+00
31,500	3,7762833E+02	9,4247400E-01	1,9484309E+03	-1,5970000E-03	5,2191710E+00

4 Modeling B

4.1 Characteristics of modeling

Modelings tested are DIS_T on meshes SEG2. The characteristics of stiffness of discrete are thus of the type: K_T_D_L, K_T_D_N, M_T_D_N.

4.2 Characteristics of the grid

Many nodes: 3, many meshes: 2, elements SEG2 : 1, elements POI1 : 1.

4.3 Boundary conditions and loadings

Nodes N1, N2, N3 are blocked in the directions Y and Z.

Nodes N1 and N3 are subjected to displacement $U(t)$, speed $V(t)$ and acceleration $\gamma(t)$ in the direction X.

The condition in function displacement of time:

$$U(t) = U_0 \cdot \sin(2\pi \cdot f \cdot t) / (2\pi \cdot f) \quad \text{with } f = 0.5 \text{ Hz} \quad \text{and } U_0 = 6.0 \text{ mm}$$

The condition of speed function of time: $V(t) = \dot{U}(t)$

The condition in acceleration function of time: $\gamma(t) = \ddot{U}(t)$

4.4 Sizes tested and results

The sizes are tested in not-regression (with the tolerances by default) and compared to the values obtained with modeling A, a precision of $1.0E-02$.

The sizes tested are:

- the displacement of the node N2,
- effort with the node N2,
- power dissipated in the non-linear device,
- the unelastic displacement of the non-linear device,
- unelastic displacement cumulated of the non-linear device.

The moments appointed to test the various sizes are those where the effort reached a extrema.

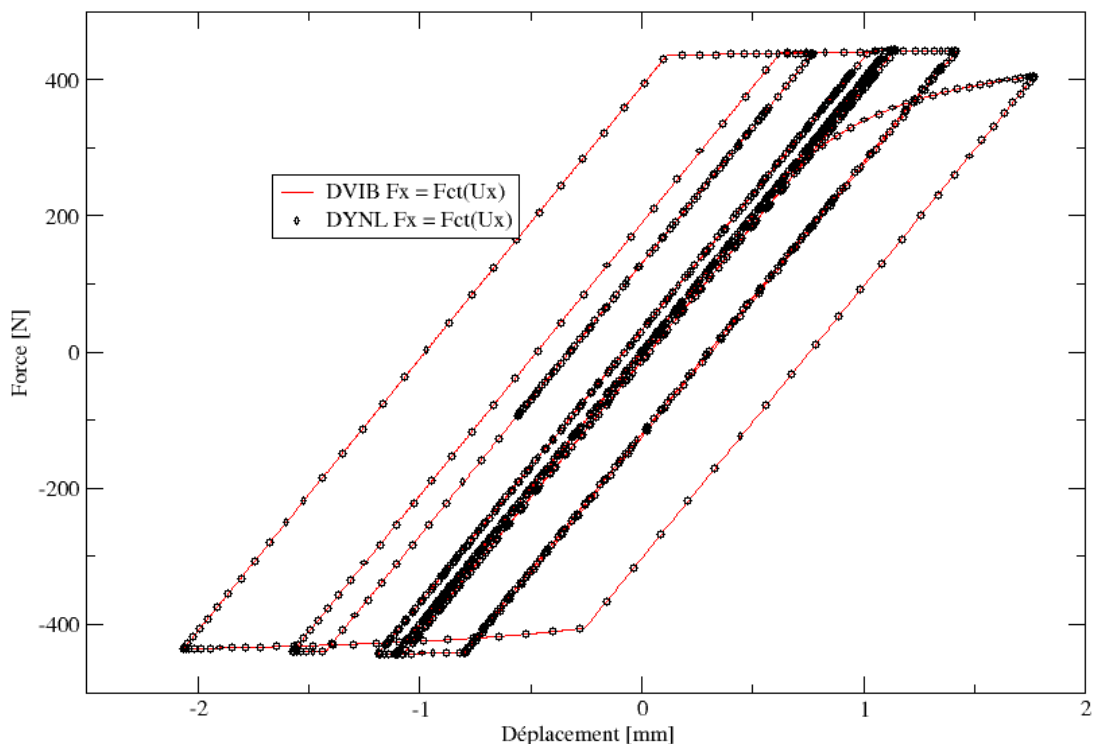


Figure 4.4-a : Comparison of the answer force-displacement to the node N2 .

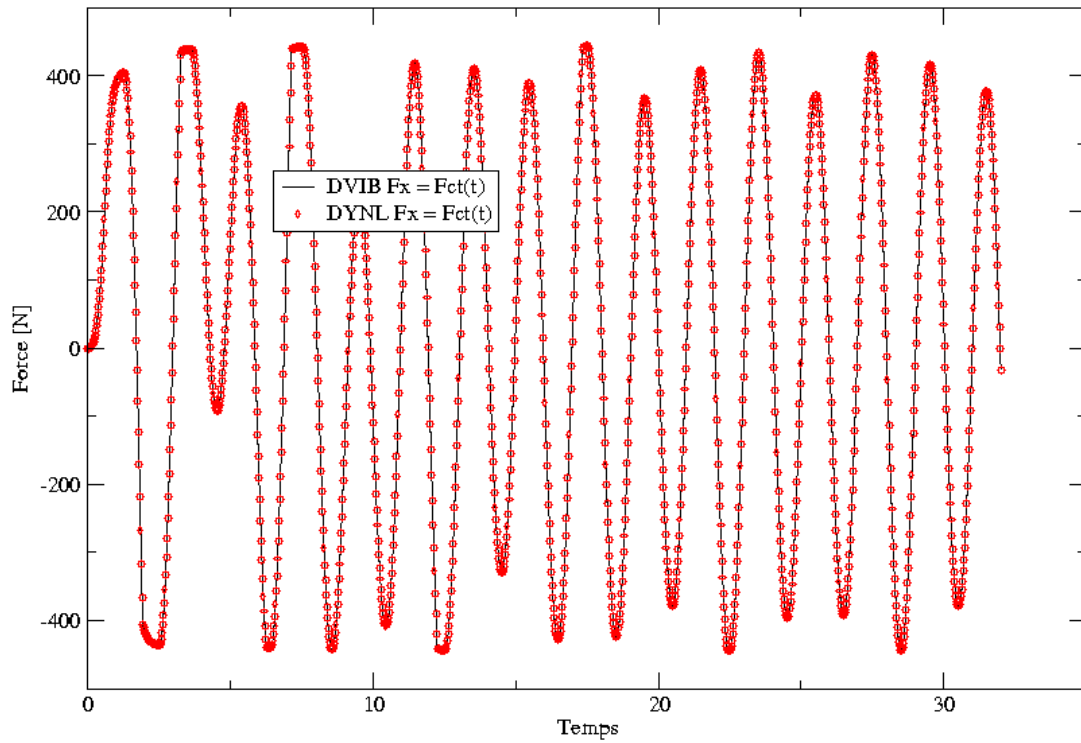


Figure 4.4-b : Comparison forces vs time with the node n2 .

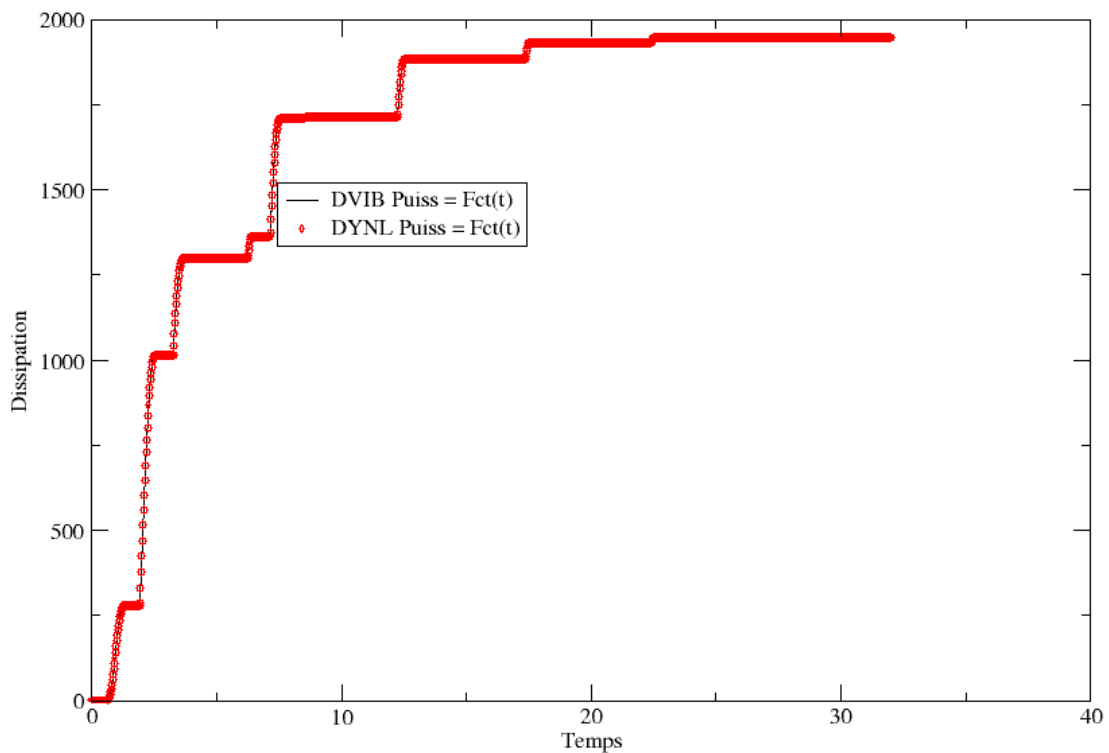


Figure 4.4-c : Comparison of dissipation vs time.

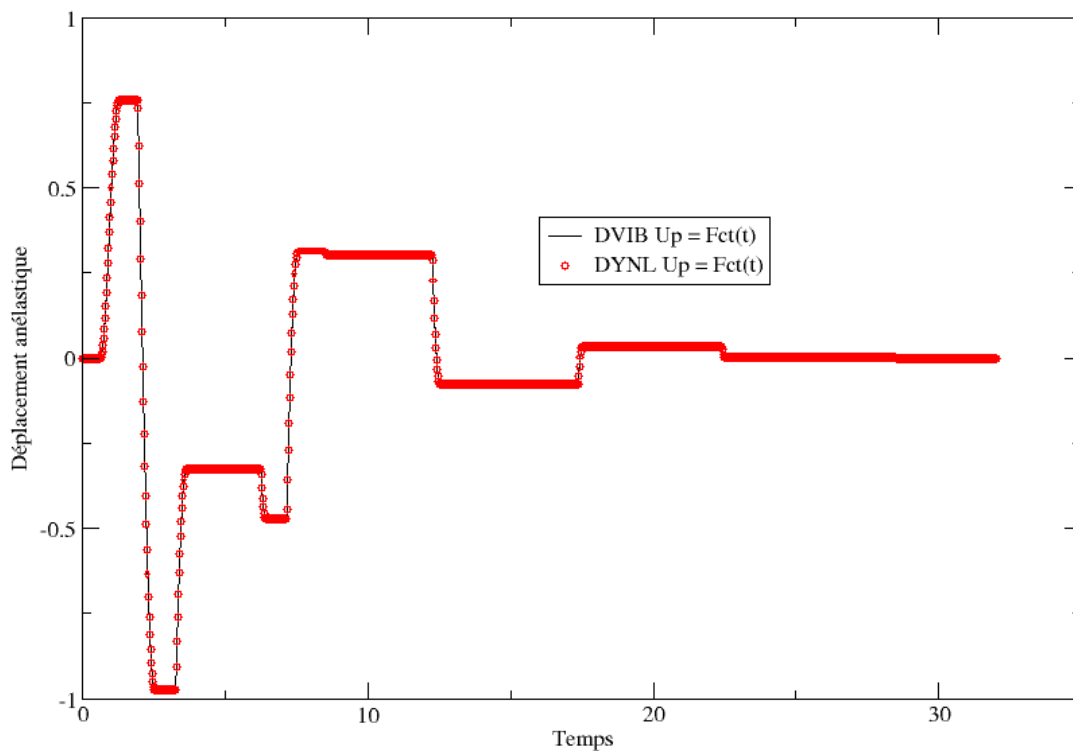


Figure 4.4-d : Comparison of unelastic displacement vs time.

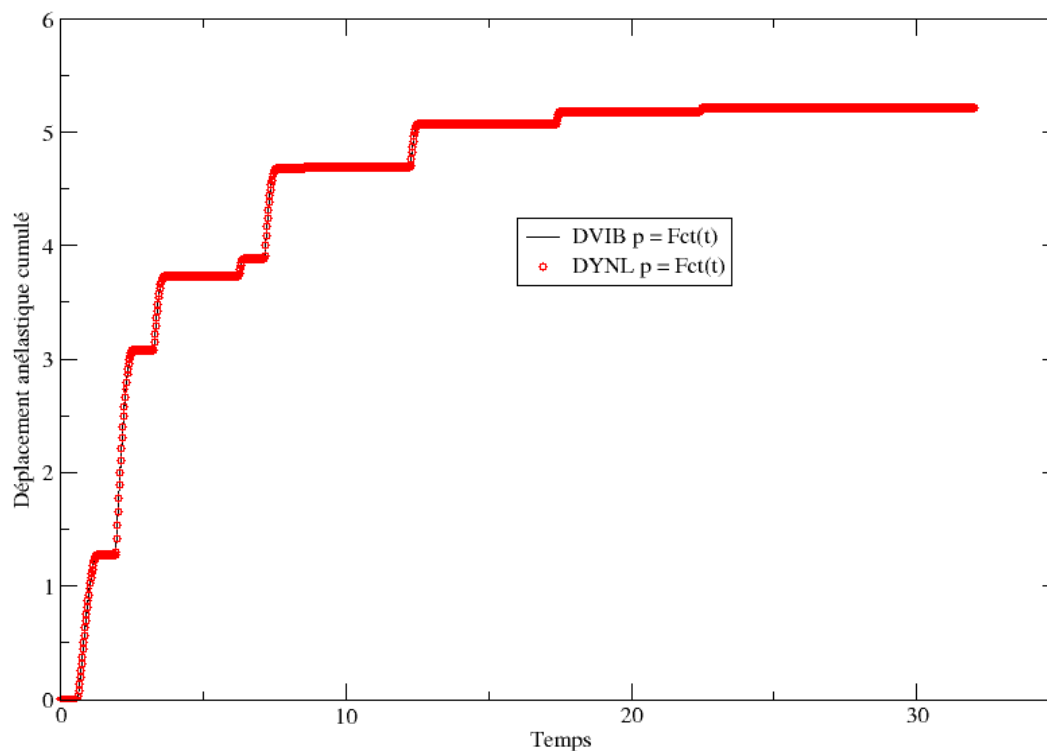


Figure 4.4-e : Comparison of unelastic displacement cumulated vs time.

5 Summary of the results

These tests make it possible to check the good performance of the discrete elements with the behavior `DIS_ECRO_TRAC` within the framework of a use with the order `DYNA_NON_LINE` and `DYNA_VIBRA`.

The order `STAT_NON_LINE` use an implicit algorithm and calculates 1281 pas de time, without adaptation of the step.

The order `DYNA_VIBRA` use an algorithm clarifies and adapts the step for the resolution of the diagram in time, that led to calculate 42796 steps of time.

Although the number of steps of time at the time of the study with `DYNA_VIBRA` that is to say 33 times more important than for the study with `STAT_NON_LINE`, the order `DYNA_VIBRA` is 10 times faster in time CPU that the order `STAT_NON_LINE`.