SDND120 - Transitory answer of a device antiseismic

Summary

An antiseismic device was tested on a mobile plate. This case test aims to reproduce this test numerically. The device is modelled by two systems mass-arises not deadened, separated by nona linearity of type antiseismic device.

One tests the discrete element in traction and compression, the calculation of the clean modes, the static modes and the calculation of the transitory answer by nonlinear modal recombination of the structure subjected to a accélérogramme. Nonthe linearity is of type `ANTI_SISM`.

The result of reference is a program MATLAB.

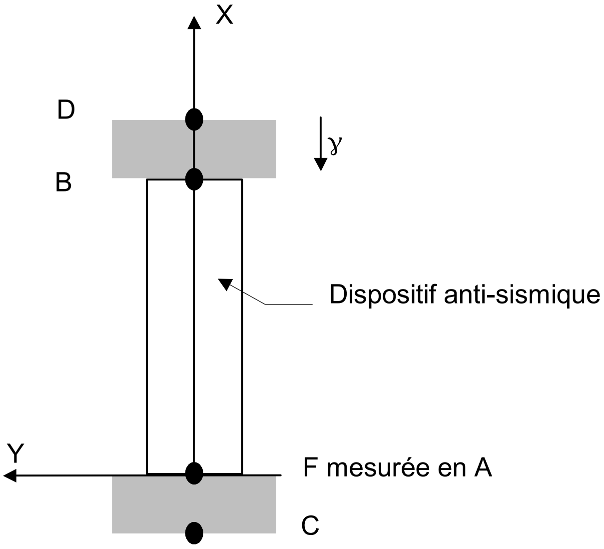
The got results are in very good agreement with the results of reference.

One also compares the results calculated with the efforts and displacements measured on an experimental device (qualitative comparison only).

1 Problem of reference

1.1 Geometry

An antiseismic device is placed between two jaws (right-angled hatched on the following figure) themselves posed on a mobile plate subjected to an acceleration imposed in direction X. It is modelled by nona linearity of type "antiseismic device" placed on both sides of a system mass-arises.



1.2 Material properties

The jaws which insert the device are modelled each one by a system mass-arises:

stiffness of connection: $k=10^{10} N/m$;
specific mass: $m=25\,kg$.

The device tested is an antiseismic device of BULGE type. Its characteristics are the following ones:

- $K1=6.10^6 N/m$ (RIGI_K1),
- $K2=0{,}53\,10^6 N/m$ (RIGI_K2),
- $Py=1200$ (SEUIL_FX),
- $C=0{,}07\,10^5$ (C),
- $alpha=0{,}2$ (PUIS_ALPHA),
- $xmax=0{,}03\,m$ (DX_MAX).

1.3 Boundary conditions and loadings

Boundary conditions

Only authorized displacements are the translations according to the axis X. Points C and D are embedded: $dx=dy=dz=0$. The other points are free in translation according to dx : $dy=dz=0$.

Loading

The point D is subjected to a transverse acceleration in the direction x $\gamma_1(t)=0{,}66\sin(\omega t)\,m/s^2$ with $\omega=2\pi$, the point C is fixed.

1.4 Initial conditions

At the initial moment, the device is at rest: with $t=0$, $dx(0)=0$, $dx/dt(0)=0$ in any point.

2 Reference solution

2.1 Method of calculating used for the reference solution

One compares the digital values with the experimental statements and the solution taken for reference obtained thanks to a script matlab.
The expression of the force of dissipation in such a device is provided by the following formula [Peckan]:

$$F_D = K_2 x + \frac{(K_1 - K_2)x}{\sqrt{1+\left(\frac{K_1 x}{P_y}\right)^2}} + C\,sign(\dot{x})\left|\dot{x}\frac{x}{x_{max}}\right|^{\alpha}$$

script matlab:

```
%cas test for antiseismic device
clear;
closed all;
%----direct calculation----
%initialisation of the parameters of
calculation
t0 = 0;
tfinal = 1. ;
not = 0.01;
tspan = t0: not: tfinal;
y0 = [0 0 0 0];
y0 = y0';
options = [];
direct %integration
[T, there] = ode23 ('fonctsism1', tspan,
y0, options);
depl1 = there (: , 1:1);
depl2 = there (: , 2:2);
vit1 = there (: , 3:3);
vit2 = there (: , 4:4);

kk1 = 6.e6;
kk2 = 0.53e6;
py = 1200;
C = 0.07e5;
xmax = 0.03;
alpha = 0.2;

for all = 1:1: length (tspan)
 depl21 = depl2 (all) - depl1 (all);
 vit21 = vit2 (all) - vit1 (all);
 g1n = (kk1-kk2) *depl21;
 g1d = sqrt (1+ ((kk1/py) *depl21) ^2);
 g1 = g1n/g1d;
   g2   =   c*sign   (vit21)   *   (ABS
(vit21*depl21/xmax))^
alpha;
 g0 = kk2*depl21;
 F (all) = g0 + g1 + g2;
end
F = f';
depl = depl2 - depl1;
```

```
function  YP  =  fonctsism1  (T,  there,
flag)
% initialization provisional
m1 = 25. ;
m2 = 25. ;
k1 = 1.e10;
k2 = 1.e10;
kk1 = 6.e6;
kk2 = 0.53e6;
py = 1200;
C = 0.07e5;
xmax = 0.03;
alpha = 0.2;
Omega = 2*pi;
%
%----direct resolution----
x0 = (0.66*sin (omega*t))/(omega*omega);
 depl21 = there (2) there (1);
 vit21 = there (4) there (3);
 g1n = (kk1-kk2) *depl21;
 g1d = sqrt (1+ ((kk1/py) *depl21) ^2);
 g1 = g1n/g1d;
   g2   =   c*sign   (vit21)   *   (ABS
(vit21*depl21/xmax))^
alpha;
 g0 = kk2*depl21;
 gg = g0 + g1 + g2;

%creation of the matrices D state
  U = [1 0 0 0;
       0 1 0 0;
       0 0 m1 0;
       0 0 0 m2];
  = [0 0 -1 0 have;
       0 0 0 -1;
       k1 0 0 0;
       0 k2 0 0];
  G = [0;
       0;
       gg + k1*x0;
      - gg];
%
%calcul of the derivative
  YP = - inv (U) *a*y + inv (U) *g;
```

2.2 Results of reference

Values maximum and RMS of relative displacements and absolutes in B , and of the effort due to the device anti - seismic.

2.3 Uncertainty on the solution

The excitation imposed on the system mass-arises is an approximation of the displacement imposed on the experimental device.

Uncertainty on the reference solution MATLAB is weak.

2.4 Bibliographical references

1) G. PEKCAN, J.B. TO BEG FOR, MR. EERI: The seismic answer of has 1: 3 scale model R.C structure with elastomeric spring dampers. - Earthquake Spexctra, vol. 11, N°2, p.249-267 - May 1995

3 Modeling A

3.1 Characteristics of modeling

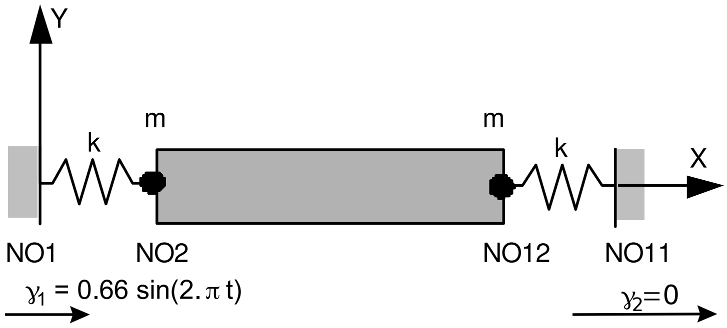


Figure 3.1-a: Modeling of the seismic anti device

The jaws which insert the device are modelled each one by a discrete element with 3 degrees of freedom `DIS_T`.
The antiseismic device is simulated via the keyword factor `ANTI_SISM` of the operator `DYNA_VIBRA`.

The node $NO1$ is subjected to an imposed acceleration $\gamma_1(t)$, the node $NO11$ with $\gamma_2(t)=0$. One calculates the relative displacement of the node $NO2$ and its absolute displacement.

Temporal integration is carried out with the algorithm of Euler and a step of time of $1{,}25.10^{-5}$ second. Calculations are filed all 80 pas de time.
A reduced damping is considered ξ_i no one for all two calculated mode.

3.2 Characteristics of the grid

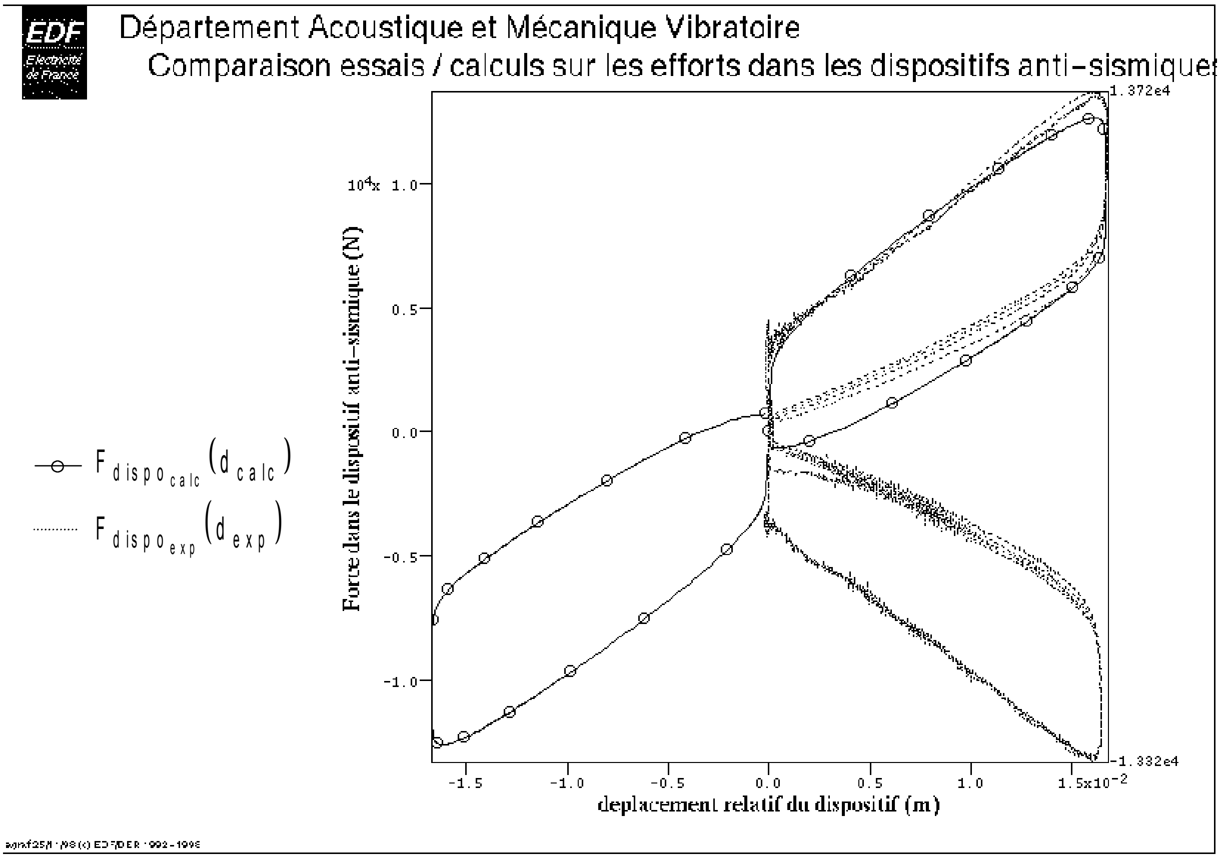
The grid consists of 4 nodes and 4 meshs of the type `DIS_T`.

3.3 Sizes tested and results

One calculates the absolute displacement of the node $NO2$: `NO2_DX_A` and effort in the device anti - seismic. One compares the values with those calculated by a function MATLAB.

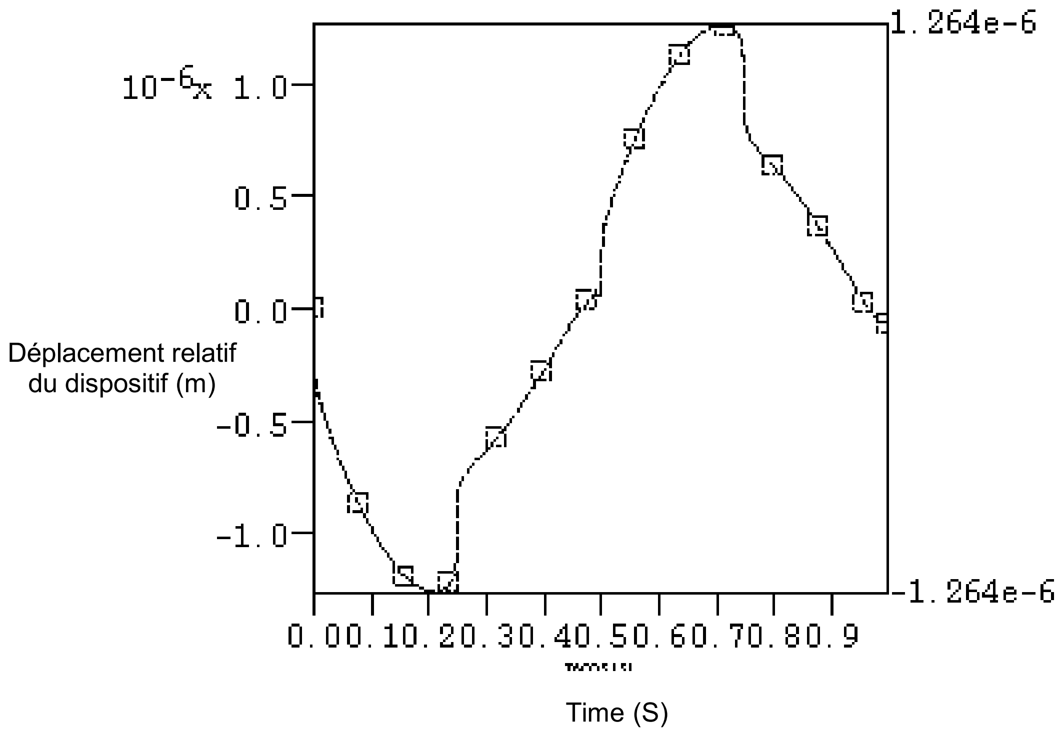
	Reference
Effort max (NR)	1,266E+04
Effort – RMS	7,912E+03
NO2_DX_A max (m)	1,670E-02
NO2_DX_A – RMS	1,180E-02
NO2_DX_R max (m)	1,266E-06
NO2_DX_R – RMS	7,798E-07

One traces the evolution of the force which is exerted in the device according to the absolute displacement of the node $NO2$. One compared to measured sizes.



Taking into account the approximation of the excitation imposed on the mobile plate in a sine, the model established in *Code_Aster* is representative of the device tested.

One also traces the temporal evolution of the displacement of the device:



4 Summary of the results

Results, in term of efforts and displacements, obtained with *Code_Aster* are comparable to those calculated by a script MATLAB. The differences raised between the calculated sizes and the experimental sizes are related to the approximation carried out on the excitation.