SDND120 - Transient response of an antiseismic device

Summarized

an antiseismic device was tested on a mobile plate. This case test aims to reproduce this test numerically. The device is modelled by two undamped systems mass-spring, separated by nona linearity of type antiseismic device.

One tests the discrete element in traction and compression, the computation of the eigen modes, the static modes and the computation of the transient response by nonlinear modal recombination of structure subjected to an accelerogram. Nonthe linearity is of type `ANTI_SISM`.

Result of reference is a program MATLAB.

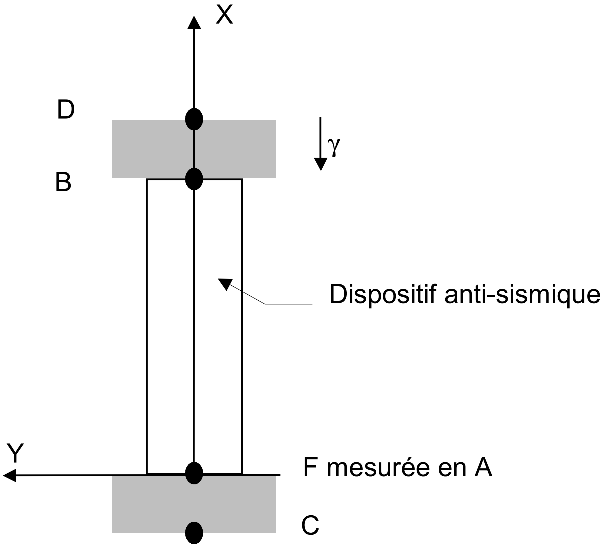
The got results are in very good agreement with the results of reference.

One also compares the results calculated with the forces 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 the direction X. It is modelled by nona linearity of type "antiseismic device" placed on both sides of a spring-mass system.



1.2 Material properties

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

stiffness of connection: $k=10^{10} N/m$;
point 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. The points C and D are clamped: $dx=dy=dz=0$. 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 initial time, the device is at rest: at $t=0$ $dx(0)=0$, $dx/dt(0)=0$ in any point.

2 Reference solution

2.1 Method of calculating used for the reference solution

One compares the numerical values with the experimental statements and the solution taken for reference obtained thanks to a script matlab.
The statement 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 computation----
%initialization of the parameters of
computation
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)    *    (ab
(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)    *    (ab
(vit21*depl21/xmax))^
alpha;
 g0 = kk2*depl21;
 gg = g0 + g1 + g2;

%creation of the matrixes 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 maximum

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

2.3 Uncertainty on the solution

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

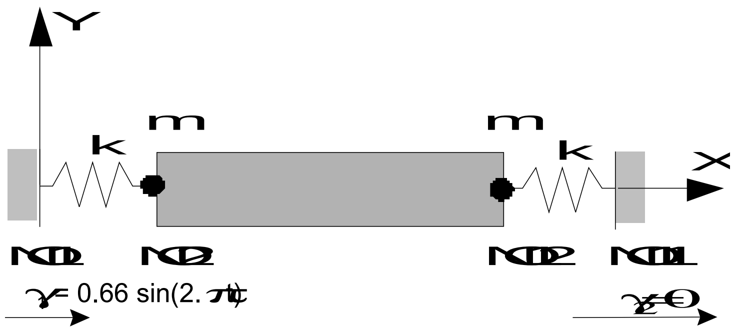
Uncertainty on the reference solution MATLAB is weak.

2.4 Bibliographical references

1) G. PEKCAN, J.B. TO BEG FOR, MR. EERI: The seismic response 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 Modelization A

3.1 Characteristic of the modelization



Appears 3.1-a: Modelization of the device the anti seismic

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 key word factor `ANTI_SISM` of 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 his absolute displacement.

Temporal integration is carried out with the algorithm of Eulerian and time step of $1{,}25.10^{-5}$ second. Computations are filed all the 80 time step.
One considers a null ξ_i reduced damping for all two calculated mode.

3.2 Characteristics of the mesh

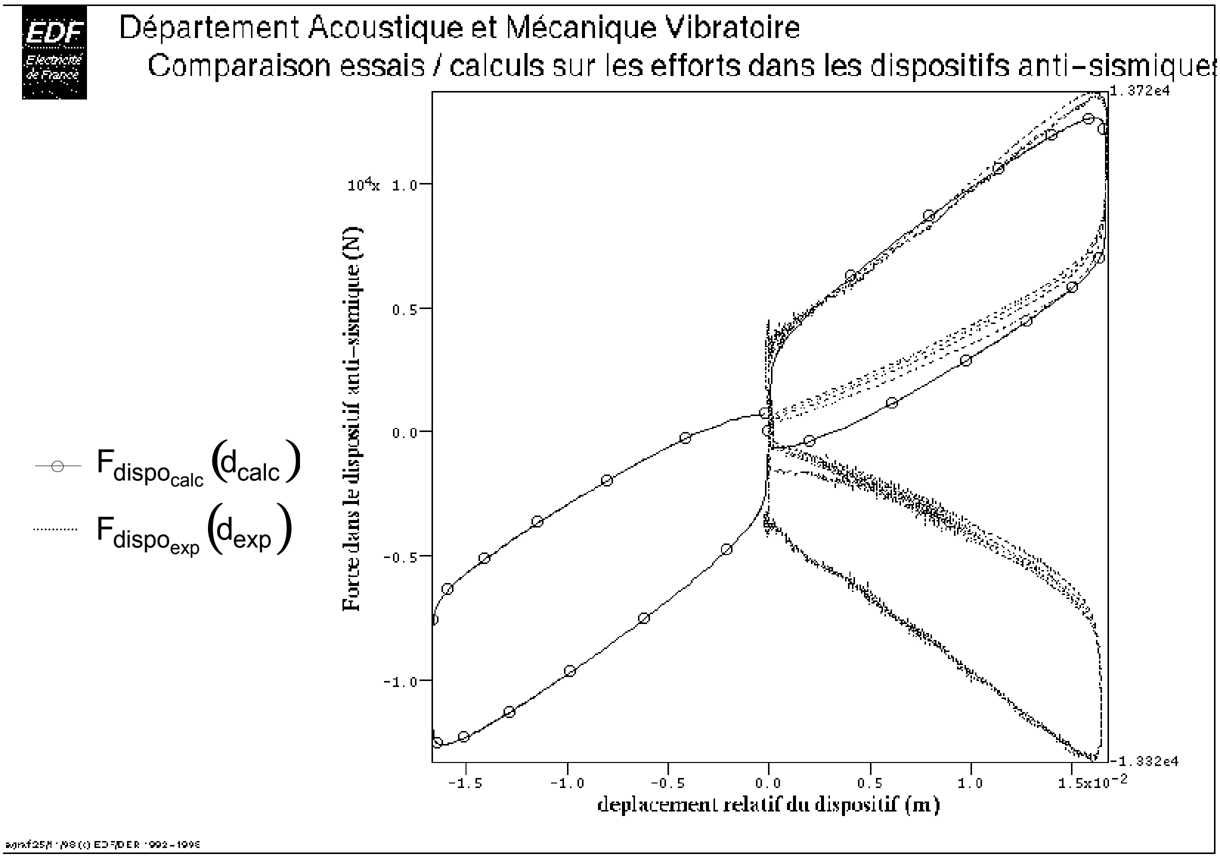
The mesh consists of 4 nodes and 4 meshes of type `DIS_T`.

3.3 Quantities tested and results

One calculates the absolute displacement of the node is outside the field of definition with a right profile of the EXCLU type node: $NO2$ `NO2_DX_A` and force in the device anti - seismic. One compares the values with those calculated by a function MATLAB.

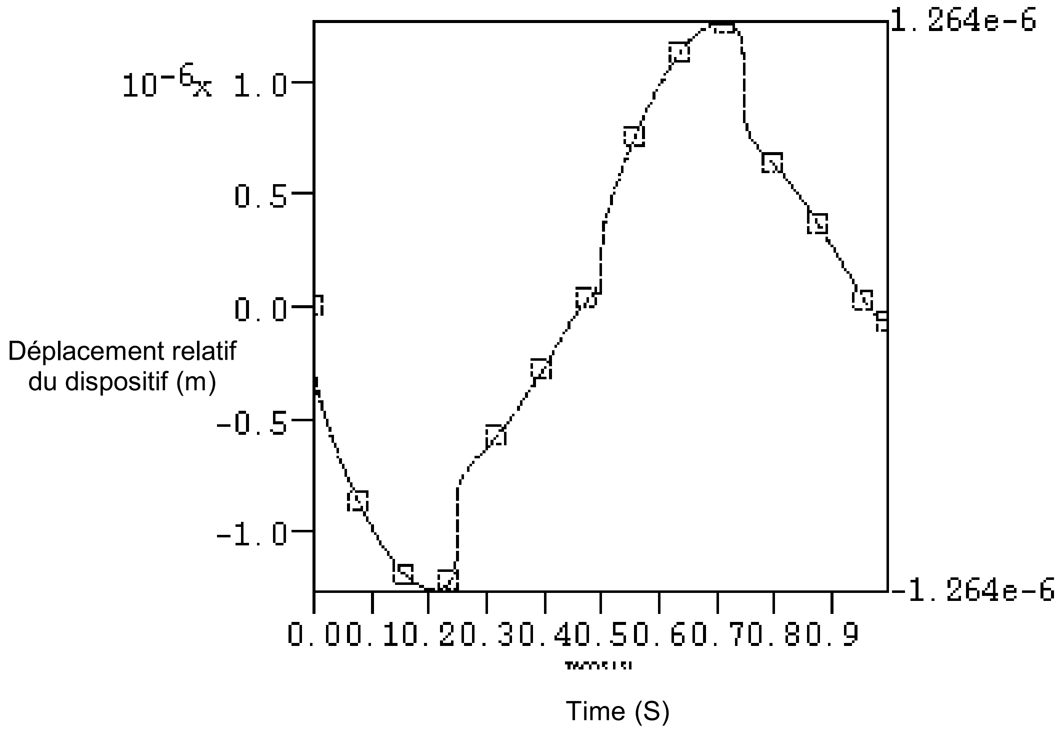
	Reference
Force max (N)	1,266E+04
Force – RMS	7,912E+03
NO2_DX_A max (m)	1,670E-02
NO2_DX_A – RMS	1,180E-02
NO2_DX_R max (m)	1,266E-06
NO2_DX_R – RMS	7,798E-07

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 quantities.



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

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