SDND103 - Post subjected to a request axial dynamics

Summary

It is a question of calculating the answer of a post subjected to an unspecified seismic loading. The post is modelled by a system mass-arises not deadened, its connection with the ground by a non-linearity of type effort - displacement.

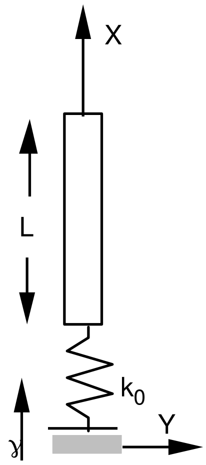
One tests the discrete element in traction and compression, the calculation of the clean modes and the calculation of the transitory answer by modal recombination with taking into account of a non-linearity of type effort-displacement. Initial speed is taken nonworthless and the loading is of standard acceleration imposed on the ground.

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

1 Problem of reference

1.1 Geometry

The system consists of a post resting on the ground and subjected to a seismic request. It is modelled by a mass, its connection with the ground by a spring k_0 whose relation of behavior translates a non-linearity of type effort-displacement.



Characteristics of the post:

length: $L=2\ m$;
section: $S=0{,}3\,m^2$.

1.2 Properties of materials

Mass of the post: $m=450\ kg$.
Stiffness within the competence of connection: $k_0=10^5\,N/m$.

1.3 Boundary conditions and loadings

Boundary conditions

Only authorized displacements are the translations according to the axis X : $dy=dz=0$.

The corrective force F_c had with nonthe linearity of the ground is defined by the following relation:

$F_c(x)=\frac{f(x_{seuil})}{x_{seuil}}-f(x)$ with, if $x>x_{seuil}$, $f(x)=k_0\left[1-\frac{|x|}{x_0}\right]x$

One takes $x_{seuil}=10^{-6}m$, $k_0=10^5 N/m$ and $x_0=0{,}1\,m$.

One thus imposes under the keyword `RELA_EFFO_DEPL` of the operator `DYNA_VIBRA` the function: $F_c(x)=\frac{k_0}{x_0}x.[|x|-x_{seuil}]$ if $|x|>x_{seuil}$

$F_c(x)=0$ if $|x|\le x_{seuil}$

Loading

The ground is subjected to an acceleration $\gamma(t)$ in the direction x , built so that the displacement of the system mass-arises that is to say sinusoidal $x=a.sin(\omega t)$ with $a=0{,}01$ and $\omega=\pi/4$.

1.4 Initial conditions

In an initial state, the system is released of its position of balance with a speed v_0 : with $t=0$, $dx(0)=0$, $v_0=dx/dt(0)=a.\omega$.

2 Reference solution

2.1 Method of calculating used for the reference solution

This test is developed in detail in the reference [bib1].

The fundamental equation of dynamics, moving relative of the system mass-arises compared to the ground is written: $\ddot{x}+\frac{k(x)}{m}x=\gamma(t)$.

For a displacement of the form $x=a.sin(\omega t)$ and $\ddot{x}=-a\omega^2\sin(\omega t)$, one obtains starting from the equation of the movement the form of the accélérogramme:

$$\gamma(t)=a\sin(\omega t)\left[-\omega^2+\frac{k_0}{m}\left(1-\frac{|a\sin(\omega t)|}{x_0}\right)\right]$$

The fundamental frequency f_0 oscillator not deadened is worth $f_0=\frac{1}{2\pi}\sqrt{\frac{k_0}{m}}$.

2.2 Results of reference

Fundamental frequency f_0 oscillator not deadened.
Displacements relating to moments 2,6,10,14 and 18 seconds.

2.3 Uncertainty on the solution

No if one calculates the integral of Duhamel analytically [bib2].

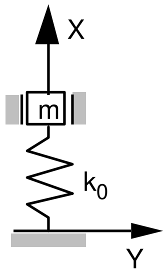
2.4 Bibliographical references

1. P. LALUQUE, P. LABBE, S. PETETIN and A. TIXIER: Seismic answer of a building engine PWR1300 by taking account of separation enters the foundation and the ground. Note SEPTEN TA83.06 (May 1984).
2. J.S. PRZEMIENIECKI: Theory of matrix structural analysis. New York, Mac Graw-Hill, 1968, p. 351-357.

3 Modeling A

3.1 Characteristics of modeling

The system mass-arises is modelled by a discrete element `DIS_T`.



Numerical data:

for the system mass-arises:	$m=450\ kg$
for the ground:	$k_0=10^5\ N/m$
for non-linearity:	$x_0=0{,}1\ m$; $a=0{,}01$ and $\omega=\pi/4$.

Temporal integration is carried out with the algorithm of Euler or the algorithm of Devogelaere and a step of times of 0.02 second. Calculations are filed all the steps of time.
A reduced damping is considered ξ_i no one for the whole of the calculated modes.

3.2 Characteristics of the grid

The grid consists of a node and a mesh of the type `POI1`.

3.3 Sizes tested and results

One checks the Eigen frequency of the oscillator as well as relative displacements of the node $NO1$ at various moments (for the algorithm of integration EULER).

Frequency (Hz)	Reference
	2.37254

Relative displacement of the node $NO1$ with the digital algorithm of integration of Euler:

Time (S)	Reference
2	0.01
6	– 0.01
10	0.01
14	– 0.01
18	0.01

Relative displacement of the node $NO1$ with the digital algorithm of integration of Devogelaere:

Time (S)	Reference

2	0.01
6	– 0.01
10	0.01
14	– 0.01
18	0.01

4 Summary of the results

One notes very a good agreement with the analytical solution (error lower than $0{,}01\%$).