SDNX100 - Checking of chaining MISS3D -*Code_Aster* in the case of a model skewer

Summary:

This test allows the checking of the chaining *Code_Aster* - MISS3D.

On the case of a building, represented by a model skewer, was implemented the calculation of the interaction ground - structure of a model 1D of building at erasing rigid, subjected to a seismic excitation, by the frequential method of coupling.

Spectra of floor, at the level to erase it and the level of the top of the structure, obtained using the chain *Code_Aster* - MISS3D are tested in non- regression.

The one second modeling uses a model made up of the preceding structure as well as super - element including a macro - element obtained starting from the temporal evolution of the impedance of ground obtained using the chain *Code_Aster* – MISS3D, then integrated by a method of Laplace. The macro - element represents the behavior of the field of ground. The answer to the seismic request is obtained by a transitory dynamic calculation in relative reference mark by means of the operator `DYNA_NON_LINE`.

The third modeling is also proposed, of which the principal difference with the preceding one is that the transitory resolution is done, this time, in absolute reference mark (imposition of the seismic force *via* the keyword `FORCE_SOL` order `AFFE_CHAR_MECA`).

Another different modeling, modeling E, at the same time makes it possible to determine new characteristics of ground starting from the levels of shearing strain in each layer and to define the seismic force by the keyword `LOAD` of `CALC_MISS`. The transitory resolution is also done in absolute reference mark.

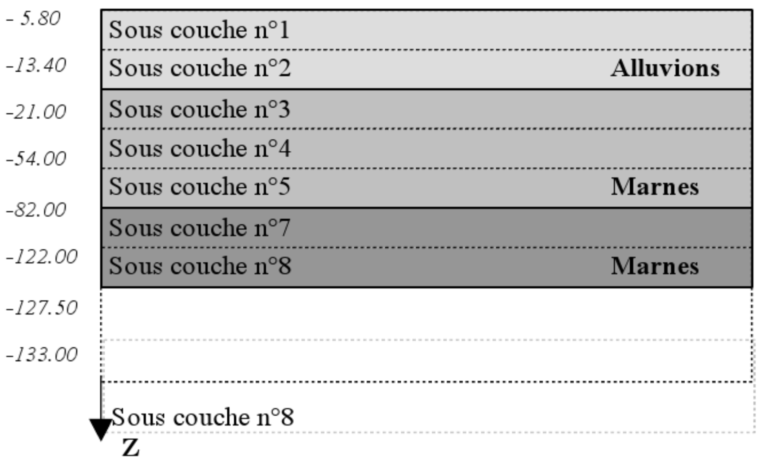
1 Problem of reference

1.1 Geometry

Software MISS3D uses the frequential method of coupling to take account of the interaction ground - structure. This method, based on under - dynamic structuring, consists in cutting out the field of study in three pennies - fields:

- ground,
- the foundation,
- the building.

Ground



Configuration of the laminated ground

The foundation

The foundation of the building is of form rectangular. The foundation raft of the building is thus represented by a rectangle of $26.40\,m$ of width and of $30.40\,m$ of length. It is cut out in 400 elements so that the maximum size of each element satisfies the criteria with propagation elastic waves (for a minimal wavelength of $9.2\mathrm{m}$ with $20\,Hz$).

The building

The building is modelled into model “skewer” 1D by a set of 6 nonheavy beams and of 7 masses.

Characteristics of the building

The characteristics of the beams and masses which were used to model the building are given in tables Ci below:

Mass	Altitude (m)	Mass ($10^6 kg$)	Mass inertias ($10^8 kg.m^2$)		
			Jxx	Jyy	Jzz
1	-5.80	6,892	3.9920	5.3000	9.2930
2	-0.45	6,179	3.0001	3.9834	6.9835
3	7.84	6,610	3.8291	5.0841	8.9132
4	12.50	4,540	2.6270	3.4919	6.1159
5	16.70	4,226	2.7261	3.2500	5.6980
6	22.35	4,706	2.7261	3.6196	6.3457
7	36.50	2,401	1.3901	1.8467	3.2368

Characteristics of the masses of the building

Beam	Surface (m^2)	Moment of inertia (m^4)		Coefficient of shearing		Constant of torsion ($10^4 m^4$)
	A	Iz	Iy	Ay	Az	Jx
1	156	11635	14648	2.25	1.79	1.70
2	154	11469	15063	2.17	1.86	1.70
3	204	13291	16398	2.65	1.61	1.70
4	200	13292	16091	2.60	1.63	1.70
5	200	13292	16091	2.60	1.63	1.70
6	83	7367	10921	1.51	1.70	1.70

Characteristics of the Beams of the building

Geometry taken into account in *Code_Aster* is that of the structure of the building like its foundation, the data geometrical and physics the soil are directly given to MISS3D.

1.2 Properties of materials

Ground

The mechanical characteristics of the layers of the model of ground which were used are summarized in table Ci - below:

Sleep	**Underlayer**	$vs(m/s)$	$E(Pa)$	$\rho(kg/m^2)$	ν	$\xi(\%)$	$h(m)$	$b(\%)$
1	1	184	$2.67\ 10^{8}$	2650	0.49	2.5	7.6	5.0
1	2	206	$3.35\ 10^{8}$	2650	0.49	2.5	7.6	5.0
2	3	340	$9.21\ 10^{8}$	2710	0.47	2.5	33.0	5.0
2	4	417	$1.39\ 10^{9}$	2710	0.47	2.5	34.0	5.0
2	5	496	$1.96\ 10^{9}$	2710	0.47	2.5	34.0	5.0
3	6	620	$3.02\ 10^{9}$	2710	0.45	2.5	5.50	5.0
3	7	870	$5.95\ 10^{9}$	2710	0.45	2.5	5.50	5.0
4	8	2500	$4.23\ 10^{10}$	2710	0.25	1.0	-	2.0

The foundation and the building

E	4. E10
ν	1.76470588 E-1
ρ	0.
α	0.

1.3 Boundary conditions and loadings mechanical

The connection between model “the skewer” 1D and the foundation raft is carried out by an embedding with the common node, one blocks this node and one imposes a solid movement of body on the foundation raft.

Transitory acceleration in the ground given by the functions LBNS and LBEW with coefficient of 1.5 .

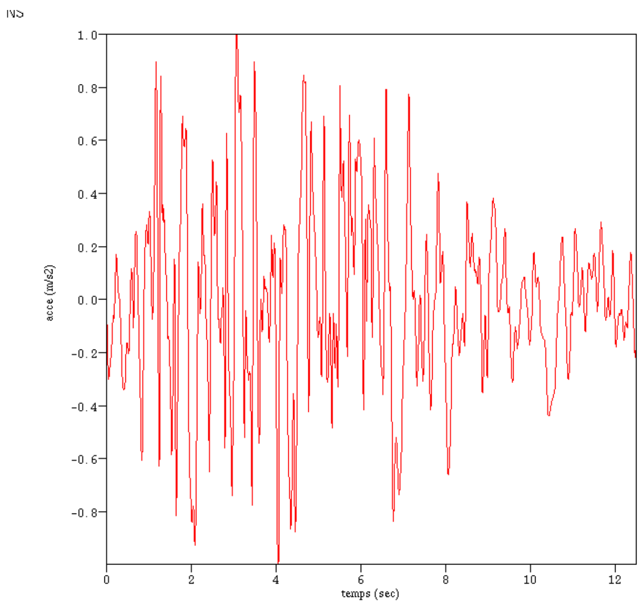


Figure 1.3-a: Accèlèrogramme LBNS

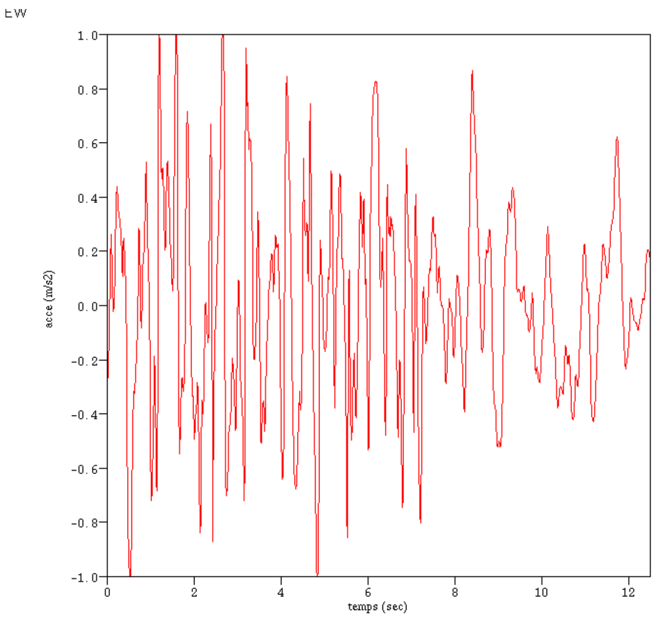


Figure 1.3-b: Accélérogramme LBEW

2 Reference solution

2.1 Results of reference

Only values of not-regression are tested. One bases oneself on the spectra of floor obtained in X and Y points located:

- at the level to erase it ($Z=-5.80\,m$),
- at the top ($Z=36.50\,m$).

The spectra are observed in the frequency band of 0.4 with $20\,Hz$. Reduced damping is taken to 5% following the two horizontal directions X and Y .

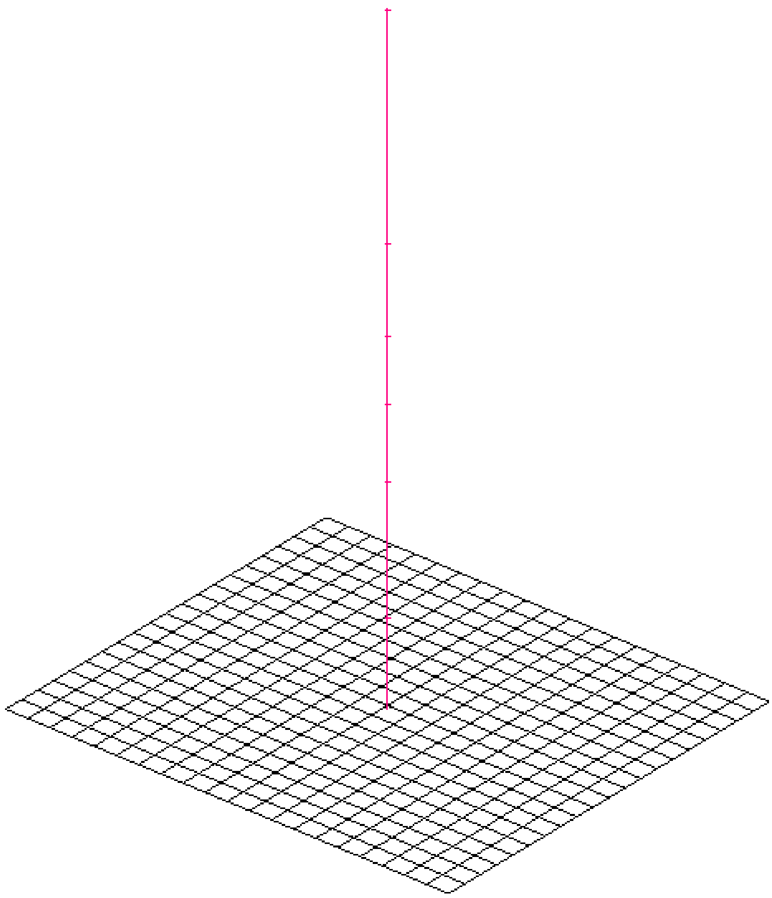
2.2 Bibliographical references

[1] G. QUILTON: "Presentation and examples of use of CLASSI: Computer code of analysis of the effects of the interaction ground - structure on the seismic answer of the buildings", E SE MT 82-01 SG 1.

[2] "Code CLASSI" Version A of the 6/18/80 - Card of introduction of the 12/19/88.

3 Modeling A

3.1 Characteristics of modeling



3.2 Characteristics of the grid

Grid provided to *Code_Aster* contains elements of the type `QUAD4` and `SEG2` respectively to model the foundation raft and model "the skewer".

3.3 Values tested

One will test (not - regression) the values of SRO following the horizontal directions in various frequencies.

4 Modeling B

4.1 Characteristics of modeling

Modeling uses a model including that of modeling A as well as a super - element including a macro - element obtained starting from the temporal evolution of the impedance of ground obtained using the chain *Code_Aster* – MISS3D, then integrated by a method of Laplace. This macro - element represents the behavior of the field of ground.

The connection between model "the skewer" 1D and the foundation raft is also carried out by an embedding with the common node, but without blocking it while imposing a solid movement of body on the foundation raft.
The answer to the seismic request is obtained by a transitory dynamic calculation by means of the operator `DYNA_NON_LINE`. The seismic forces are defined there by a load of vector assembled mono-support calculated by *Code_Aster*. The load of force interns ground defined by `FORCE_SOL` and the seismic load are introduced by 2 occurrences of the keyword `EXCIT` in a dynamic resolution in relative reference mark. The place of interface ground-structure is defined implicitly starting from the data of the super - element by means of the keyword `SUPER_MAILLE`.

4.2 Characteristics of the grid

Grid provided to *Code_Aster* is the same one as that of modelings A and B. the final grid contains in more one super - mesh being pressed on the macronutrient representing the behavior of the field of ground defined previously.

4.3 Values tested

The tests are of type not - regression.

5 Modeling C

5.1 Characteristics of modeling

Modeling uses a model including that of modeling A as well as a super - element including a macro - element obtained starting from the temporal evolution of the impedance of ground obtained using the chain *Code_Aster* – MISS3D, then integrated by a method of Laplace. This macro - element represents the behavior of the field of ground.

The connection between model "the skewer" 1D and the foundation raft is also carried out by an embedding with the common node, but without blocking it while imposing a solid movement of body on the foundation raft.
The answer to the seismic request is obtained by a transitory dynamic calculation by means of the operator `DYNA_NON_LINE`. The internal load of force of ground and the seismic load are introduced by only one occurrence of the keyword `EXCIT` with the keyword `FORCE_SOL` in a dynamic resolution in absolute reference mark.

The seismic load is calculated by `CALC_MISS` with the keyword factor `EXCIT_SOL` and she is written in a file of which the logical unit is specified by the keyword `UNITE_RESU_FORC`. This seismic load will be then provided to `DYNA_NON_LINE` starting from a temporal evolution of seismic forces contained in the file of which the unit is given by the operand `UNITE_RESU_FORC` of `FORCE_SOL`. The place of interface ground-structure is defined explicitly by means of the keyword `GROUP_NO_INTERF`.

In order to reduce time CPU, one voluntarily degrades the resolution while exploiting several parameters: one decreases the final moment, one increases the step of time as well as the step of filing (which controls sampling directly for `CALC_MISS`). Time CPU can thus be reduced to less than 3 minutes, whereas to find the reference solution it takes more than one hour.

In the command file, one recalls in comment the values of the parameters to be used to find this precise solution. The associated tests are also indicated in comment.

5.2 Characteristics of the grid

Grid provided to *Code_Aster* is the same one as that of modeling A. the final grid contains in more one super - mesh being pressed on the macronutrient representing the behavior of the field of ground defined previously.

5.3 Values tested

As the precision of the solution is voluntarily degraded, in order to reduce time CPU, one cannot compare oneself any more directly with the results of modeling B. the tests will be thus all of type not regression. The values tested are extracted, at certain frequencies, of the following SRO X and Y at the level to erase it and top. The values are not pointed out here because it are given in the command file.

6 Modeling D

6.1 Characteristics of modeling

Modeling D is in any point identical to modeling C. the only difference lies in the option of parallelization MPI.

7 Modeling E

7.1 Characteristics of modeling

Modeling uses a model including that of modeling A as well as a super - element including a macro - element obtained starting from the temporal evolution of the impedance of ground obtained using the chain *Code_Aster* – MISS3D, then integrated by a method of Laplace. This macro - element represents the behavior of the field of ground.

The connection between model "the skewer" 1D and the foundation raft is also carried out by an embedding with the common node, but without blocking it while imposing a solid movement of body on the foundation raft.
The answer to the seismic request is obtained by a transitory dynamic calculation by means of the operator DYNA_NON_LINE. The internal load of force of ground is introduced by only one occurrence of the keyword EXCIT by a load defined with the keyword FORCE_SOL in a dynamic resolution in absolute reference mark.

The seismic load is calculated in the form of mechanical load by CALC_MISS with the option TYPE_RESU=' CHARGE' starting from the temporal integration of the seismic forces contained in the file of which the logical unit is specified by the keyword UNITE_RESU_FORC. It is combined with the double temporal integration of acceleration in the form of displacement imposed behind the keyword FONC_SIGNAL. The place of interface ground-structure is defined explicitly by means of the keyword NOEUD_AFFE. There are two seismic loads corresponding each one to the components according to X and Y . These seismic loads are also introduced like 2 occurrences of keyword EXCIT of the operator DYNA_NON_LINE.

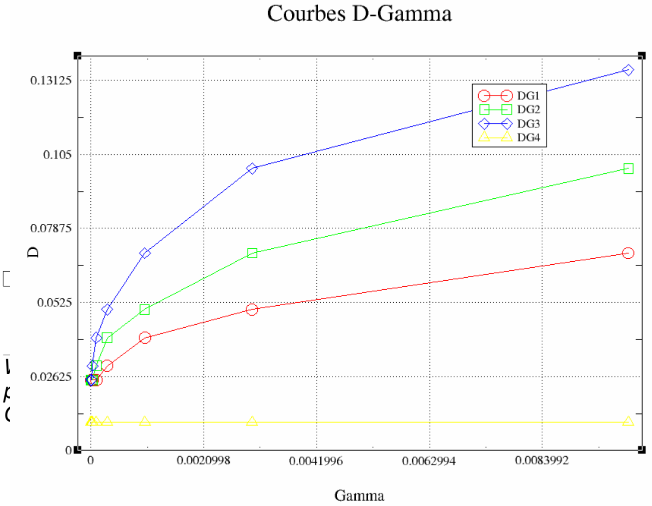
In order to reduce time CPU, one voluntarily degrades the resolution while exploiting several parameters: one decreases the final moment, one increases the step of time as well as the step of filing (which controls sampling directly for CALC_MISS). Time CPU can thus be reduced to less than 3 minutes, whereas to find the reference solution it takes more than one hour.

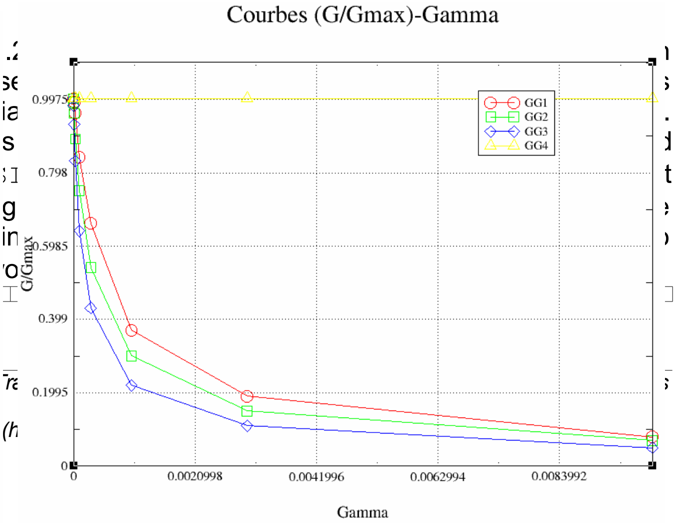
In the command file, one recalls in comment the values of the parameters to be used to find this precise solution. The associated tests are also indicated in comment.

7.2 Characteristics of the grid

Grid provided to *Code_Aster* is the same one as that of modeling A. the final grid contains in more one super - mesh being pressed on the macronutrient representing the behavior of the field of ground defined previously.
One also introduces the grid of the auxiliary model of a column of ground reproducing the discretization of the layers of the model of ground. This model is used as a basis for the determination of the levels of maximum acceleration and deformation by layer during the transitory transient of calculation under the effect of a horizontal acceleration imposed on the surface of the ground in free field.

7.3 New properties of the ground





Characteristic D-Gamma and (G/Gmax) - Gamma by material constitutive of the layers

New characteristics of ground obtained by DEFI_SOL_EQUI are summarized in the following table:

NUME_COUCHE	EPAIS	RHO	E	NU	AMOR_HYST
1	1.90000E+00	2.65000E+03	2.56763E+08	4.90000E-01	5.00000E-02
2	1.90000E+00	2.65000E+03	2.25568E+08	4.90000E-01	5.00000E-02
3	1.90000E+00	2.65000E+03	1.98765E+08	4.90000E-01	5.47801E-02
4	1.90000E+00	2.65000E+03	1.83055E+08	4.90000E-01	5.82985E-02
5	1.90000E+00	2.65000E+03	2.31426E+08	4.90000E-01	5.79648E-02
6	1.90000E+00	2.65000E+03	2.22460E+08	4.90000E-01	5.97225E-02
7	1.90000E+00	2.65000E+03	2.04392E+08	4.90000E-01	6.23900E-02
8	1.90000E+00	2.65000E+03	1.87825E+08	4.90000E-01	6.50673E-02
9	4.12500E+00	2.71000E+03	6.15324E+08	4.70000E-01	6.63939E-02
10	4.12500E+00	2.71000E+03	5.83092E+08	4.70000E-01	6.95971E-02
11	4.12500E+00	2.71000E+03	5.59976E+08	4.70000E-01	7.21068E-02
12	4.12500E+00	2.71000E+03	5.39958E+08	4.70000E-01	7.44424E-02
13	4.12500E+00	2.71000E+03	5.24714E+08	4.70000E-01	7.63330E-02
14	4.12500E+00	2.71000E+03	5.12672E+08	4.70000E-01	7.79009E-02
15	4.12500E+00	2.71000E+03	5.06281E+08	4.70000E-01	7.87613E-02
16	4.12500E+00	2.71000E+03	5.05413E+08	4.70000E-01	7.88799E-02
17	4.25000E+00	2.71000E+03	9.13351E+08	4.70000E-01	6.73677E-02
18	4.25000E+00	2.71000E+03	8.96583E+08	4.70000E-01	6.84698E-02
19	4.25000E+00	2.71000E+03	8.71497E+08	4.70000E-01	7.01927E-02
20	4.25000E+00	2.71000E+03	8.50005E+08	4.70000E-01	7.17446E-02
21	4.25000E+00	2.71000E+03	8.34856E+08	4.70000E-01	7.28834E-02
22	4.25000E+00	2.71000E+03	8.24663E+08	4.70000E-01	7.36717E-02
23	4.25000E+00	2.71000E+03	8.17051E+08	4.70000E-01	7.42724E-02
24	4.25000E+00	2.71000E+03	8.12355E+08	4.70000E-01	7.46482E-02
25	4.25000E+00	2.71000E+03	1.31552E+09	4.70000E-01	6.61268E-02
26	4.25000E+00	2.71000E+03	1.30561E+09	4.70000E-01	6.65663E-02
27	4.25000E+00	2.71000E+03	1.27845E+09	4.70000E-01	6.78033E-02
28	4.25000E+00	2.71000E+03	1.25198E+09	4.70000E-01	6.90568E-02
29	4.25000E+00	2.71000E+03	1.23178E+09	4.70000E-01	7.00478E-02
30	4.25000E+00	2.71000E+03	1.21696E+09	4.70000E-01	7.07943E-02
31	4.25000E+00	2.71000E+03	1.20658E+09	4.70000E-01	7.13272E-02
32	4.25000E+00	2.71000E+03	1.19954E+09	4.70000E-01	7.16937E-02
33	5.50000E+00	2.71000E+03	1.72153E+09	4.50000E-01	8.53685E-02
34	5.50000E+00	2.71000E+03	4.24357E+09	4.50000E-01	7.09641E-02
35	1.00000E+01	2.71000E+03	4.23000E+10	2.50000E-01	2.00000E-02

New constitutive material characteristics for each soil horizon

7.4 Values tested

As the characteristics of the ground were changed, which correspond now to a more flexible ground, one cannot compare oneself any more directly with the results of modeling C. the tests will be thus mainly of standard not-regression.
However, one preserves like reference AUTRE_ASTER the values obtained by modeling C. the values tested are extracted, at certain frequencies, of the peaks of following SRO X and Y at the level to erase it and top. The values are not pointed out here because they are given in the command file.
This makes it possible to note that the peaks of SRO obtained by modeling E are, as expected because of flexibility of the ground, low from approximately 20 to 30 % than those obtained for modeling C.

8 Modeling F

8.1 Characteristics of modeling

In this case, no modification is introduced in terms of modeling. The goal of this CAS-test is to test the keyword FACTEUR_INTERPOL and PCENT_FREQ_CALCUL macro-order CALC_MISS. The fact of interpolating the impedances of ground thus makes it possible to reduce final time CPU of the case test.

8.2 Characteristics of the grid

Grid provided to *Code_Aster* is the same one as that of modeling B. the final grid contains in more one super - mesh being pressed on the macronutrient representing the behavior of the field of ground defined previously.

8.3 Values tested

The values tested are of type AUTRE_ASTER and correspond to the values obtained with *Code_Aster* for modeling B without interpolation of the impedances of ground.

9 Modeling G

9.1 Characteristics of modeling

In this case, no modification is introduced in terms of modeling. The goal of this CAS-test is to test the macro-order PRE_SEISME_NONL, in particular, the option associated with the transition statics-dynamics (option STAT_DYNA). This option makes it possible to integrate in the macro-order the realization of static calculation (STAT_NON_LINE) and of two dynamic calculations (DYNA_NON_LINE) necessary to stabilize the answer the passage statics-dynamics set up by the user apart from the macro-order enters.

9.2 Characteristics of the grid

Since the impedances of ground are not calculated on a dynamic basis of reduction (REDUC_DYNA_ISS = 'NOT' and REDUC_DYNA_IFS = 'NOT' in PRE_SEISME_NONL), the grid does not contain fictitious meshs.

9.3 Values tested

In order to ensure that the transition statics-dynamics occurs correctly, it is checked that, at the end of the second call to DYNA_NON_LINE carried out inside the macro-order, the values of displacement in the center of the foundation raft remain constant and the values of acceleration tend towards zero.

10 Summary of the results

Spectra of floor obtained by a transitory dynamic calculation by means of the operator DYNA_NON_LINE, on a model made up of the preceding structure as well as super-element including the macro - element representing the behavior of the field of ground, remain rather close and with an acceptable precision to those obtained directly using the chain *Code_Aster* – MISS3D, that one is in relative reference mark or absolute reference mark for the transitory resolution.