SDLX103 – Interaction structure - ground - structure between two hidden buildings

Summary:

This test contributes to the validation of the chaining *Code_Aster* - MISS3D by the frequential method of coupling. It represents a standard case of coupling by the ground between 2 hidden buildings, i.e. a case of interaction structure - ground - structure. One tests 2 twin buildings represented each one by a model 1D of type model-skewer, inserted each one of $5\mathrm{m}$ in a laminated ground. A harmonic force, of constant module for each frequency understood enters $0,1\,Hz$ and $20\,Hz$, is imposed on the top of one of the buildings.

One tests the module of the direct answer at the top of excited building as well as the module of the answer coupled at the top of adjacent building compared to the values obtained at the time of a test routine on structures representative of nuclear buildings subjected to the seismic risk: program NUPEC [bib1]. The agreement between calculations and tests is very satisfactory.

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 the dynamic under-structuring, consists in cutting out the field of study in three under-fields:

- ground,
- the foundation,
- the building.

Ground

The ground corresponds to the profile with 10 horizontal layers represented on [Figure 1.1-a] below:

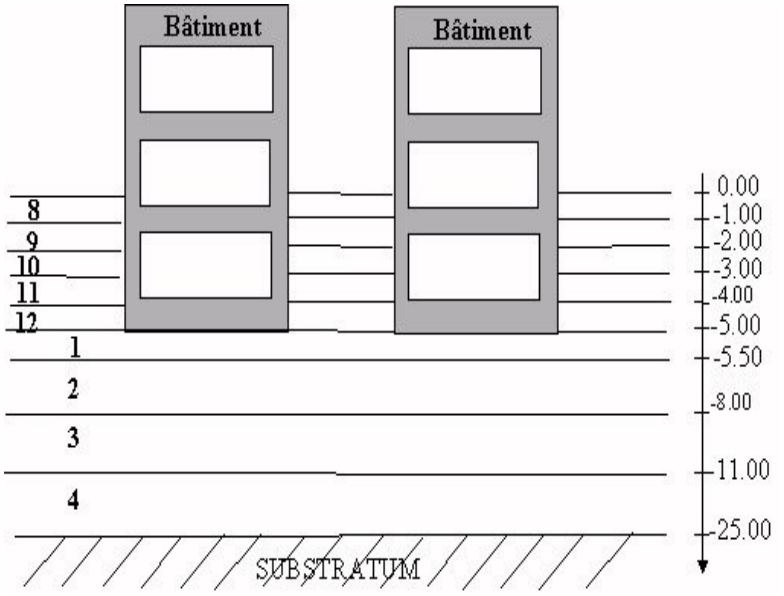

Figure 1.1-a: Configuration juxtaposed buildings [bib1]

n° Couche	Epaisseur (m)	E (MPa)	ρ (kg/m3)	2β (%)	ν
1	0,50	97,776	1940	10	0,120
2	2,50	614,930	1940	10	0,371
3	3,00	1015,100	1940	4	0,415
4	14,00	10190,000	2210	4	0,386
5 (substratum)	27,75	15010.00	2210	4	0,343
8	1,00	117,880	1770	10	0,386
9	1,00	190,270	1770	10	0,279
10	1,00	207,000	1770	10	0,265
11	1,00	224,190	1770	10	0,251
12	1,00	248,670	1770	10	0,272

Table 1.1-a: ground in configuration buried foundation [bib1]

The foundation

The surface foundation of the 2 buildings is represented on [Figure 1.1-b] below. Two models surface of the foundation supplement two model skewers of the buildings ([Figure 1.1-c] hereafter). To the initial surface model of 128 elements of plates representing the base of the double foundation, one adds 320 elements of plate very low thickness to represent the side walls of the depression of $5\,m$ [Figure 1.1-b]. One juxtaposes the two configurations of type building only buried by leaving between each foundation raft a distance from $60\,cm$.

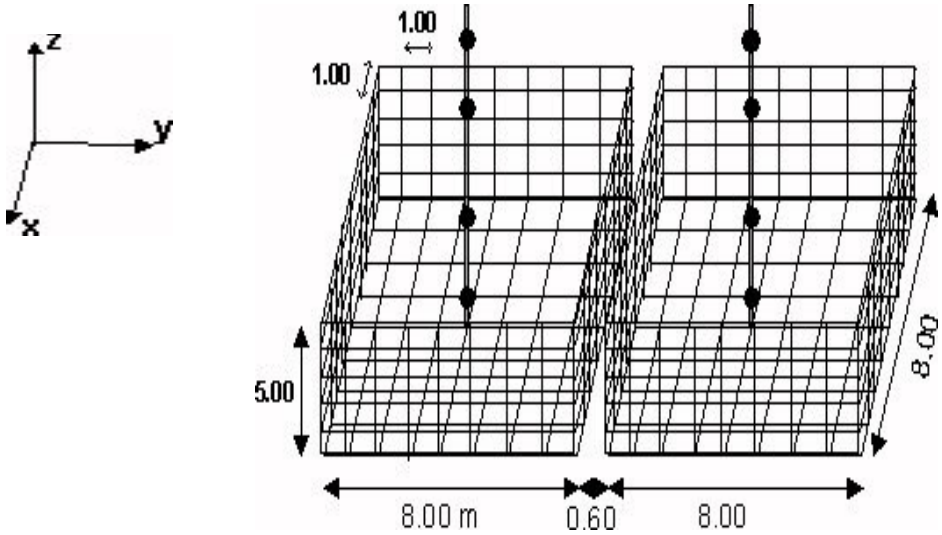

Figure 1.1-b: Surface grid of the foundation

The building

The building is modelled in 1D by a model skewer made up of 7 nonheavy beams of 5 types and 4 specific masses as shows it hereafter it [Figure 1.1-c]:

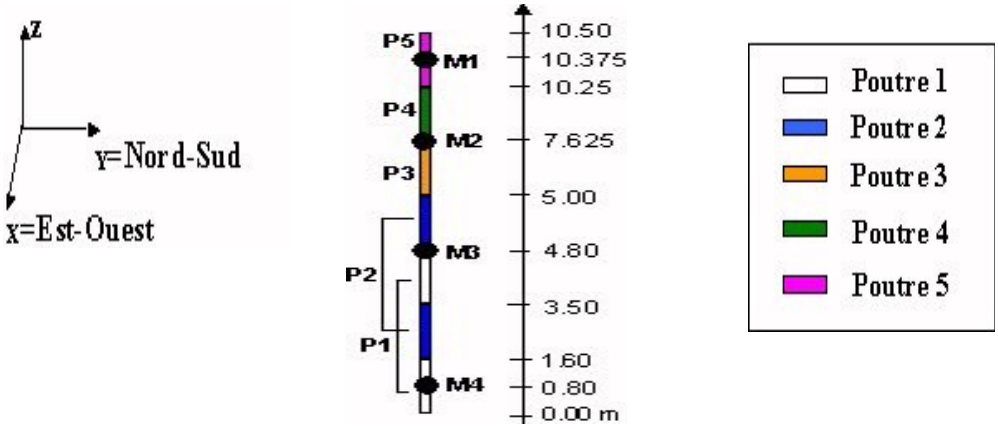

Figure 1.1-c: Modeling of each building

Characteristics of the building:

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

Mass	Altitude	Mass	Mass inertias ($10^3 kg.m^2$)		
	(m)	($10^3 kg$)	J_{xx}	J_{yy}	J_{zz}
M1	10,38	79,25	410,72	482,34	893,06
M2	6,25	104,09	574,75	694,04	1268,79
M3	4,8	156,71	1020,85	1071,22	2092,07
M4	0,8	316,97	1846,7	1844,02	3690,72

Table 1.1-b: characteristics of the masses of the model skewer provided by NUPEC [bib1]

Beam	Surface (m^2)	Moment of inertia (m^4)		Coefficient of shearing		Constant of torsion (m^4)
	A	I_z	I_y	A_y	A_z	J_x
P1	59,50	341,33	341,33	1/0,93	1/0,93	682,70
P2	8,28	39,51	54,77	2,94	1,47	94,30
P3	63,19	341,33	341,33	1/0,99	1/0,99	682,70
P4	19,78	148,34	149,14	2,13	2,11	297,50
P5	64,00	341,33	341,33	1,00	1,00	682,70

Table 1.1-c: characteristics of the beams of the model skewer provided by NUPEC [bib1]

Geometry taken into account in *Code_Aster* is that of the structure of the buildings like their foundation. The geometrical and physics data 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 those indicated in table 1.

The foundation and the building

E	$31000\ MPa$
NAKED	0,16
RHO	0.
ALPHA	0

1.3 Boundary conditions and loadings mechanical

Each of the 2 connections between a model 1D and its foundation is carried out by a solid condition of connection between the foundation and the common node with the model of building. One blocks this node and one imposes a solid movement of body on the foundation raft.

One excites the top of the model of the building in the direction Y, which is the direction of separation between the buildings, with a harmonic loading $F = F_o \sin \alpha t$ of which the module of the force F_o is of $10 kN$ with a pulsation which varies 0 with $20 Hz$ by step of $0.1 Hz$.
For the buried configuration, the excitation is applied in the following way:

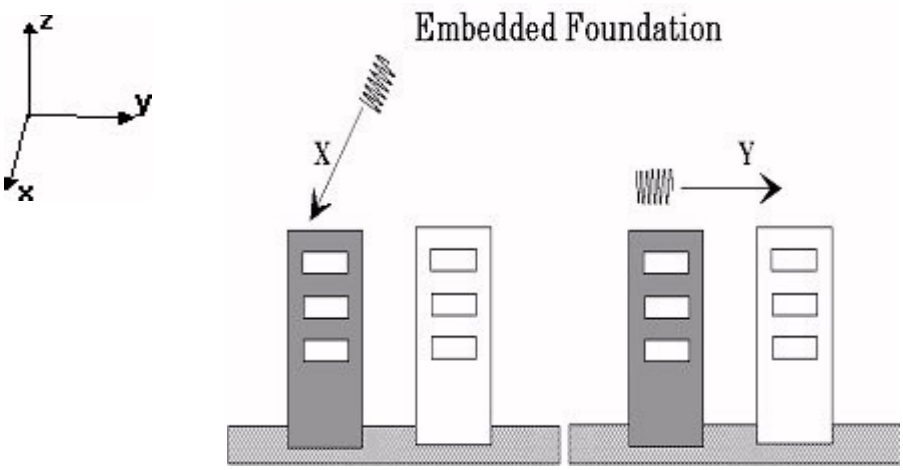

Figure 1.3-a: configuration of the harmonic excitation in buried foundation

2 Reference solution

2.1 Results of reference

One tests the maximum of the module of the direct answer at the top of excited building as well as the maximum of the module of the answer coupled at the top of adjacent building compared to the values obtained at the time of a test routine on structures representative of nuclear buildings subjected to the seismic risk: program NUPEC [bib1].

The results of calculations were the object of a detailed study.

2.2 Bibliographical references

1. Y. KITADA & al: “Models test one dynamic structure-structure interaction of nuclear power seedling buildings”. Nuclear Engineering and Design 192 (1999) 205-216.

3 Modeling A

3.1 Characteristics of modeling

The characteristics used and the grid are those deduced from the data of [§1].

3.2 Characteristics of the grid

Grid provided to *Code_Aster* contains meshs of the type SEG2 to model the structure building with elements of beam and meshs of the types QUAD4, TRIA3 to model the foundation with elements DKT. It is important to have directed the elements of surface of the foundation with normal returning in the ground. The meshs of the side walls representing the depression are generated by the same vertical generator as MISS3D requires it.

4 Results of modeling A

4.1 Values tested

The values tested relate to the module of the direct maximum answer to the top of the excited building (not $A1$) and maximum answer coupled with the top of the close building modulates it (not $B1$).

Identification	Reference	*Aster*	Difference
$MYA1$ ($12.5\,Hz$)	27,583	29,123	5.6%
$MYB1$ ($12.5\,Hz$)	18,048	19,259	6.7%

5 Summary of the results

The paces of the variations of the modules of the answers calculated to the top of each building, (direct answer and coupled answer, respectively in blue and green) are represented on the same graph as those obtained by the test routine NUPEC (respectively in red and black). The agreement between calculations and tests is very satisfactory with a relative variation around 6%.

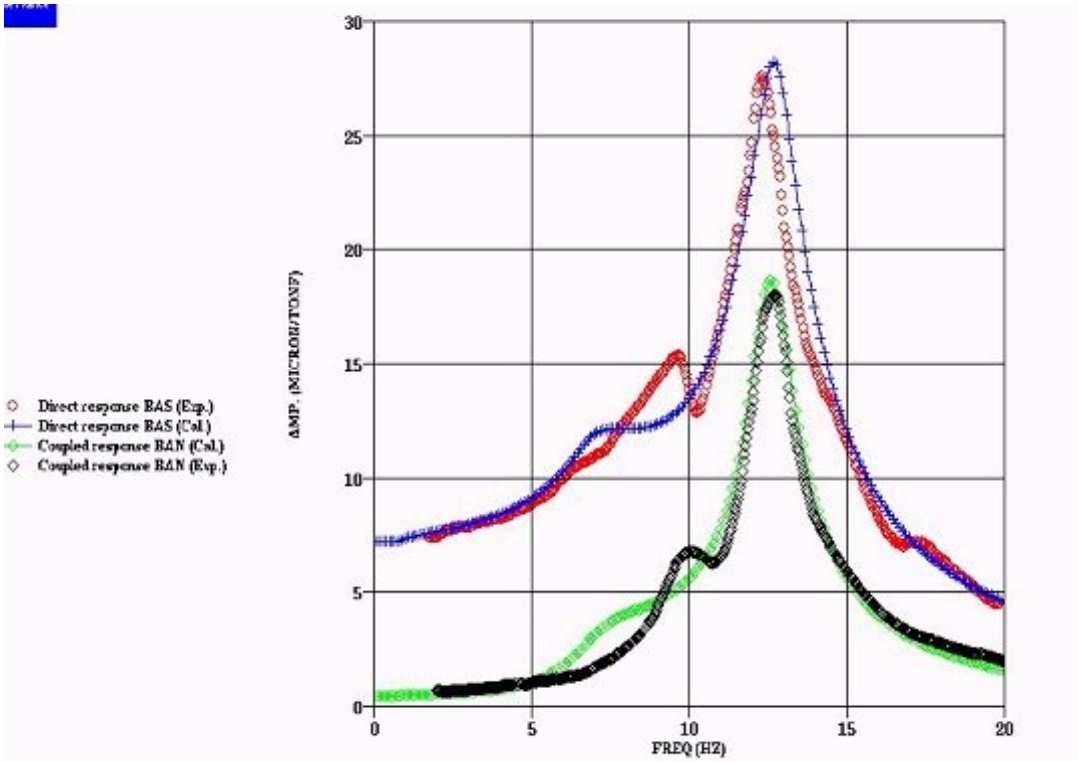

Figure 5: calculated and measured evolutions module of the answers direct and coupled with the harmonic excitation in foundation buried in the direction Y.