SDLX102 – Interaction structure - ground - parametric structure between two buildings of level

Summary:

This test contributes to the validation of the chaining Aster -MISS3D by the frequential method of coupling. It represents a standard case of coupling by the ground enters two buildings, is a case of interaction structure - ground - structure. One tests two twin buildings represented each one by a model 1D of type model-skewer, positioned each one on a ground laminated and connected by a surface foundation of the same surface. A harmonic force, of constant module for each frequency understood enters $0,1$ and $20\,Hz$, is imposed on the top of one of the buildings. In order to accelerate the test, one will calculate only two frequencies: 7.3 Hz and 10.4 Hz.

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 for various modules of the intermediate foundation of connection compared to the values obtained with the extreme conditions of connection between the two buildings: completely uncoupled or completely rigid foundations. It is shown that while dividing or while multiplying per 1000 the module constitutive of the structures to assign it to the intermediate foundation of connection with flexible assumption of foundation, one obtains the two borderline cases of connection between the two buildings with only rigid assumption of foundation.

1 Problem of reference

1.1 Geometry

The software Aster - 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 pennies - fields:

- ground,
- the foundation,
- the building.
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With the dealt problem exploits data resulting from experiments carried out by NUPEC [bib2].

Ground

The ground corresponds to the profile with 5 horizontal layers represented on figure Ci - below:

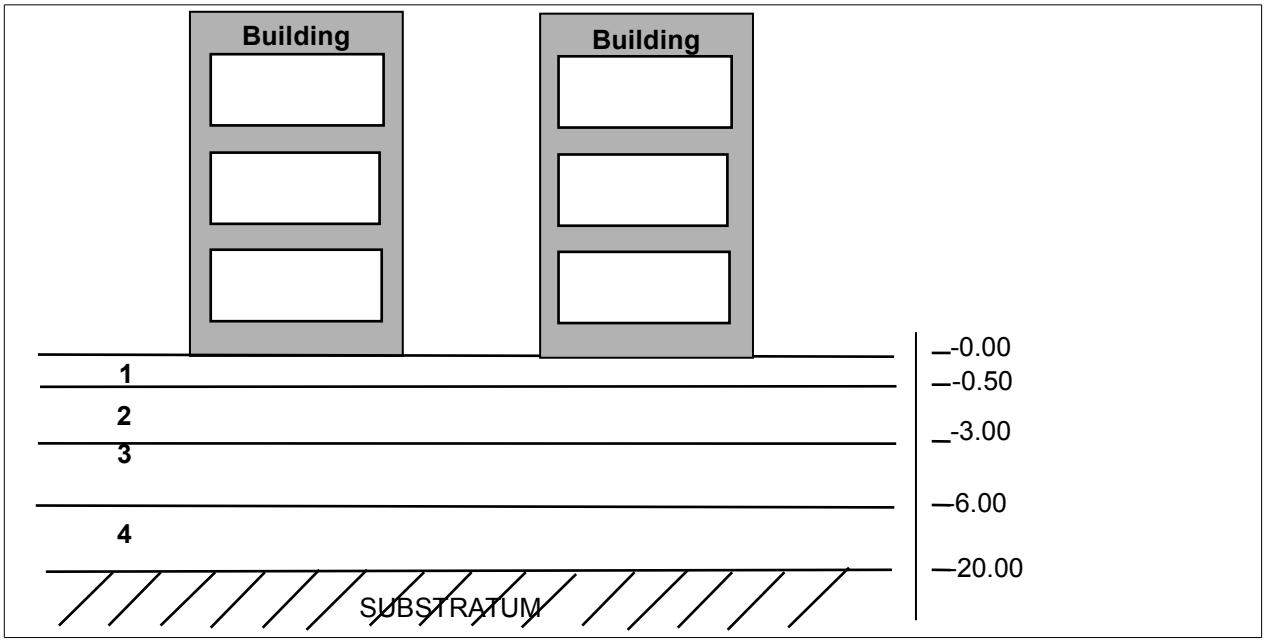

Figure 1.1-a: Configuration juxtaposed buildings [bib2]

	Thickness (m)	Young modulus (MPa)	Density (kg/m^3)	Damping hysteretic (%)	Poisson's ratio
1	0,50	97,78	1940	10	0,120
2	2,50	614,93	1940	10	0,371
3	3,00	1015,10	1940	4	0,415
4	14,00	10190,00	2210	4	0,386
5 (substratum)	27,75	15015,00	2210	4	0,343

Table 1 .1-a: ground with buried foundation [bib2]

The foundation

The surface foundation of two buildings is data on [Figure 1.1-b] below. Two surface models of the foundation supplement two model skewers of the buildings hereafter [Figure 1.1-c]). To the initial surface model of 128 elements representing the base of the double rigid foundation, one adds 64 surface elements having for thickness the base of the foundations, that is to say 1.6 m, to represent the intermediate foundation of flexible connection of variable rigidity parameterized by his Young modulus and embedded in the double rigid foundation [Figure 1.1-b]. One juxtaposes the two surface configurations of building alone by leaving between each foundation raft a distance from $8\,m$.

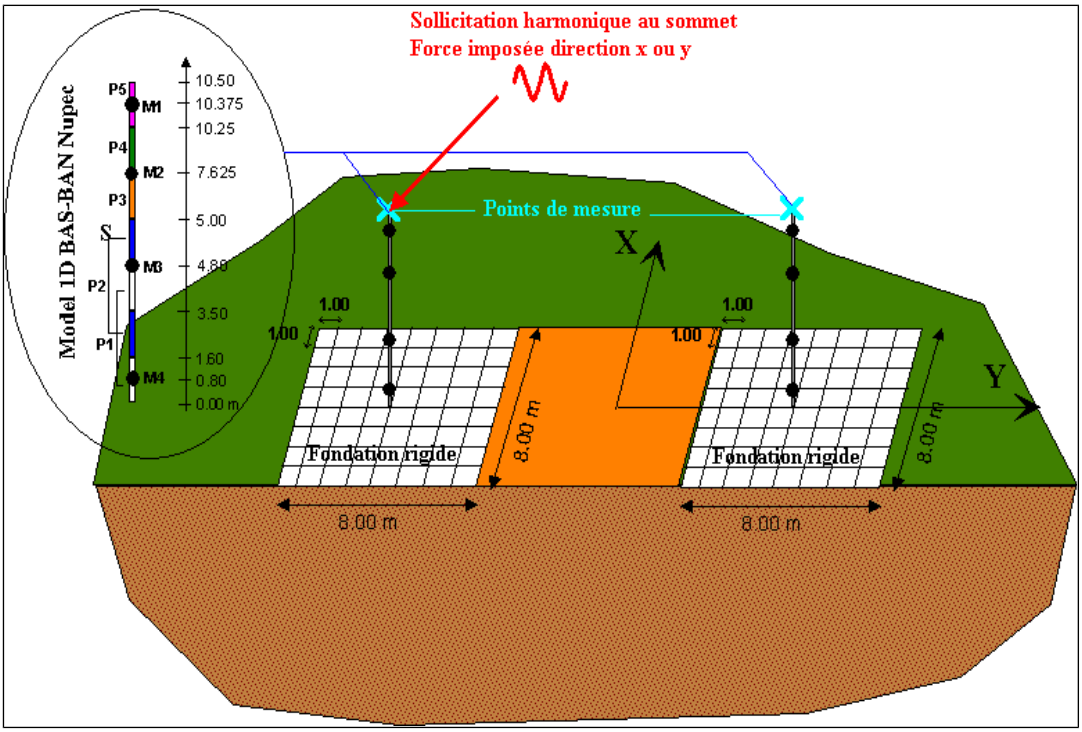

Figure 1.1-b: Models and surface grids of the foundations

The building

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

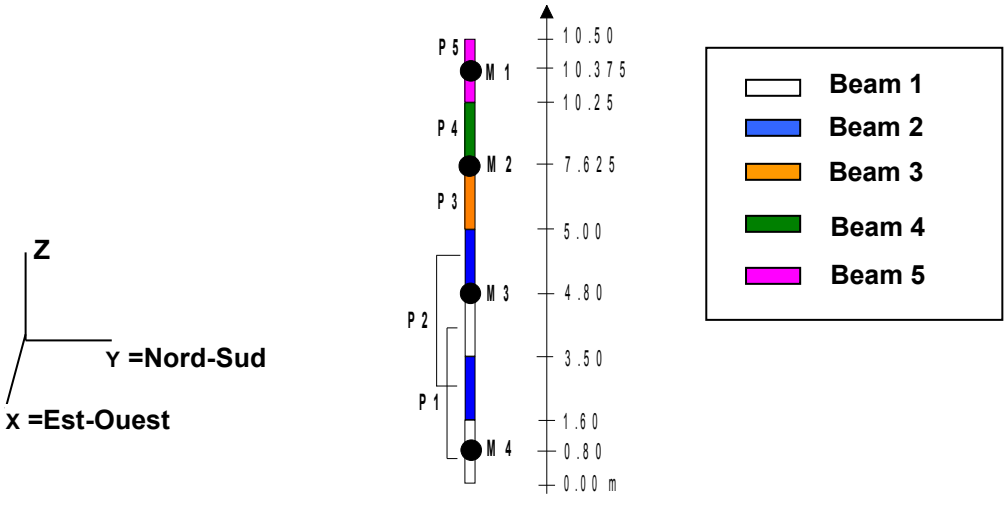

Figure 1.1-c: Modeling of each building

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 [bib2]

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	2,94	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	2,13	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 [bib2]

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 MISS_3D.

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 1.1-a.

The double rigid foundation and the building

E	$31000\,MPa$
NAKED	0.16
RHO	0.
ALPHA	0.

The module E intermediate flexible foundation of connection is parameterized like a multiple of 10 of the module of the building with a multiplicative factor ranging between 0,001 and 1000.

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. To calculate the constrained modes associated with the foundation with connection, one also blocks the degrees of freedom of translation of the foundation of connection.
One excites the top of the model of the building in the horizontal directions X and Y with a harmonic loading $F = F_o \sin \omega t$ 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 $0,1 Hz$. That returns in *Code_Aster* to impose a loading of the type FORCE_NODALE and to transmit in IMPR_MISS_3D the assembled vector corresponding with a unit multiplying function in frequency.
The excitation is applied as indicated to [Figure 1.1-b].

2 Reference solution

2.1 Results of reference

Frequential method of coupling between MISS3D and *Code_Aster* is described in the reference document [bib1].

One tests (not-regression) 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.

The computation results on these structures were the object of a detailed study.

2.2 Bibliographical references

1. D. CLOUTEAU: “Manual of reference of MISS3D – version 6.3 – Power station Searches SA”

2. 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 the paragraph [1]. In order to accelerate the test, one will calculate only two frequencies: 7.3 Hz and 10.4 Hz. The impedances are used and seismic forces calculated on the waiter of reference aster5, these data are thus provided as starter of the test and the call to CALC_MISS having been used to calculate them is thus commented on.

3.2 Characteristics of the grid

Grid provided to *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.

3.3 Sizes tested and results

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

4 Summary of the results

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 for various modules of the intermediate foundation of connection. They are compared with the values obtained with the extreme conditions of connection between the 2 buildings: completely uncoupled or completely rigid foundations. One shows on the figures below that while dividing or while multiplying per 1000 the module constitutive of the structures to assign it to the intermediate foundation of connection with flexible assumption of foundation, one obtains the 2 borderline cases of connection between the 2 buildings (rigid assumption of foundation).

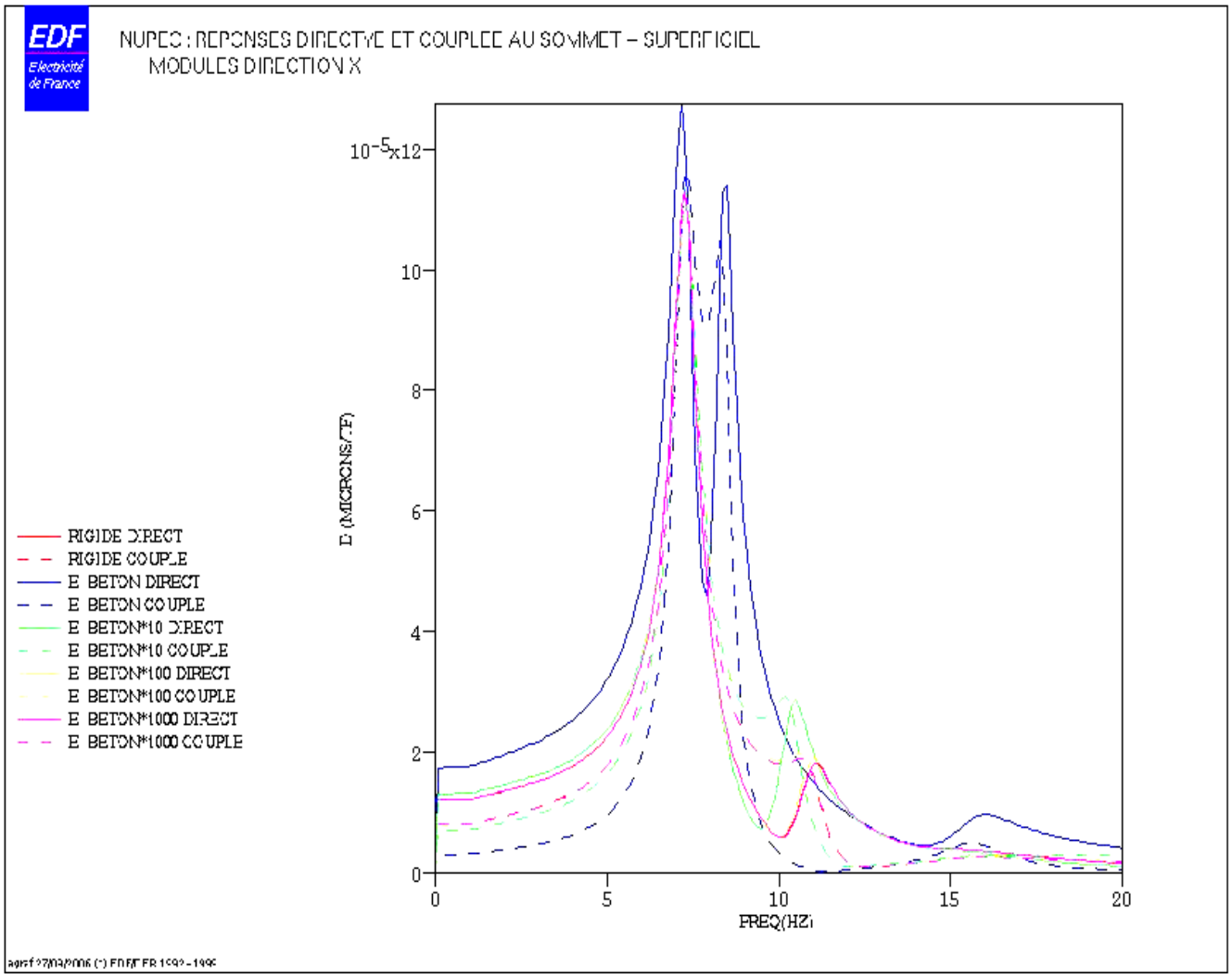

Figure 4-a: Comparison of the modules of the answers direct and coupled with the harmonic excitation between rigid case and flexible case with increase in the module of the foundation of connection in the direction X.

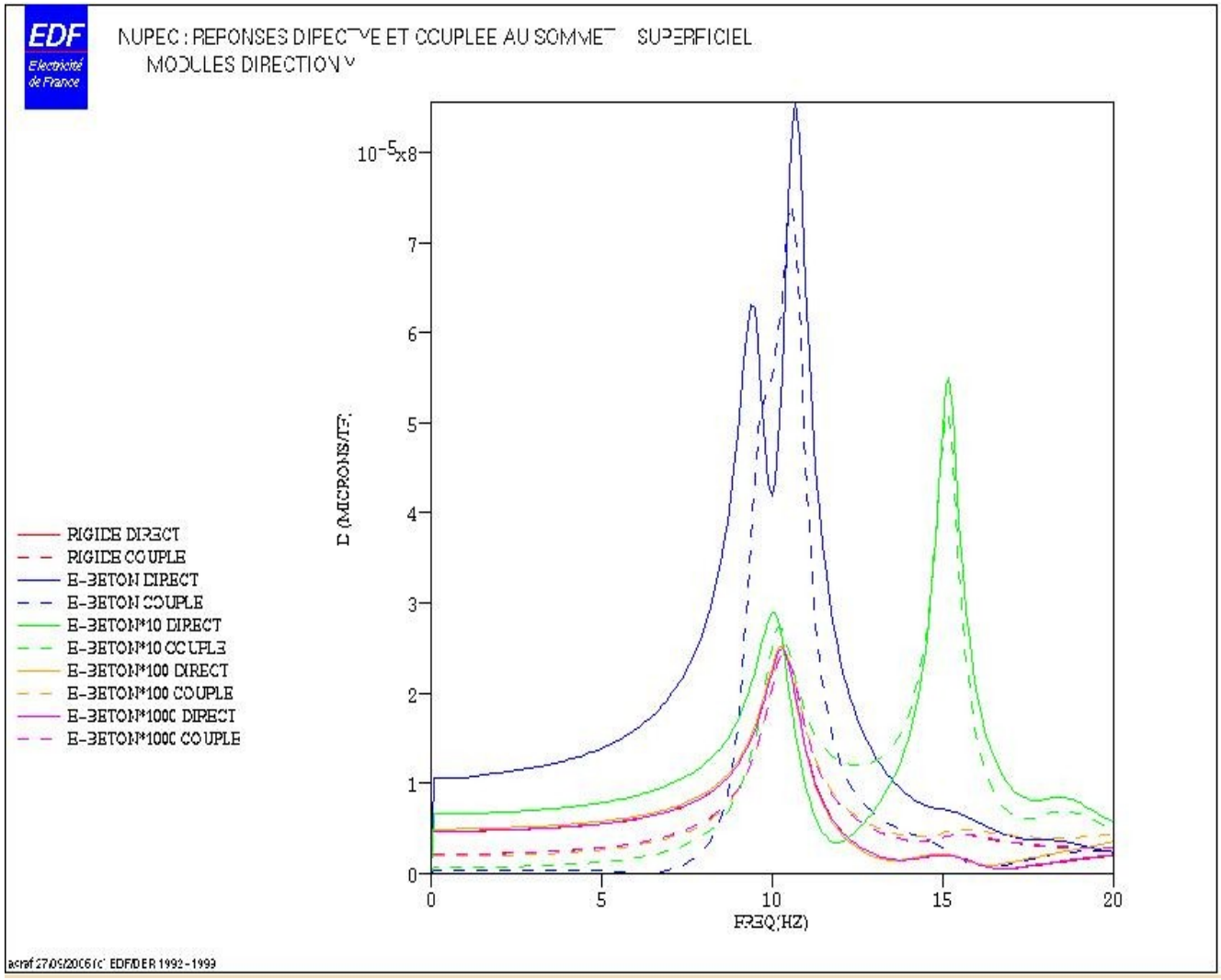

Figure 5-b: Comparison of the modules of the answers direct and coupled with the harmonic excitation between rigid case and flexible case with increase in the module of the foundation of connection in the direction Y.

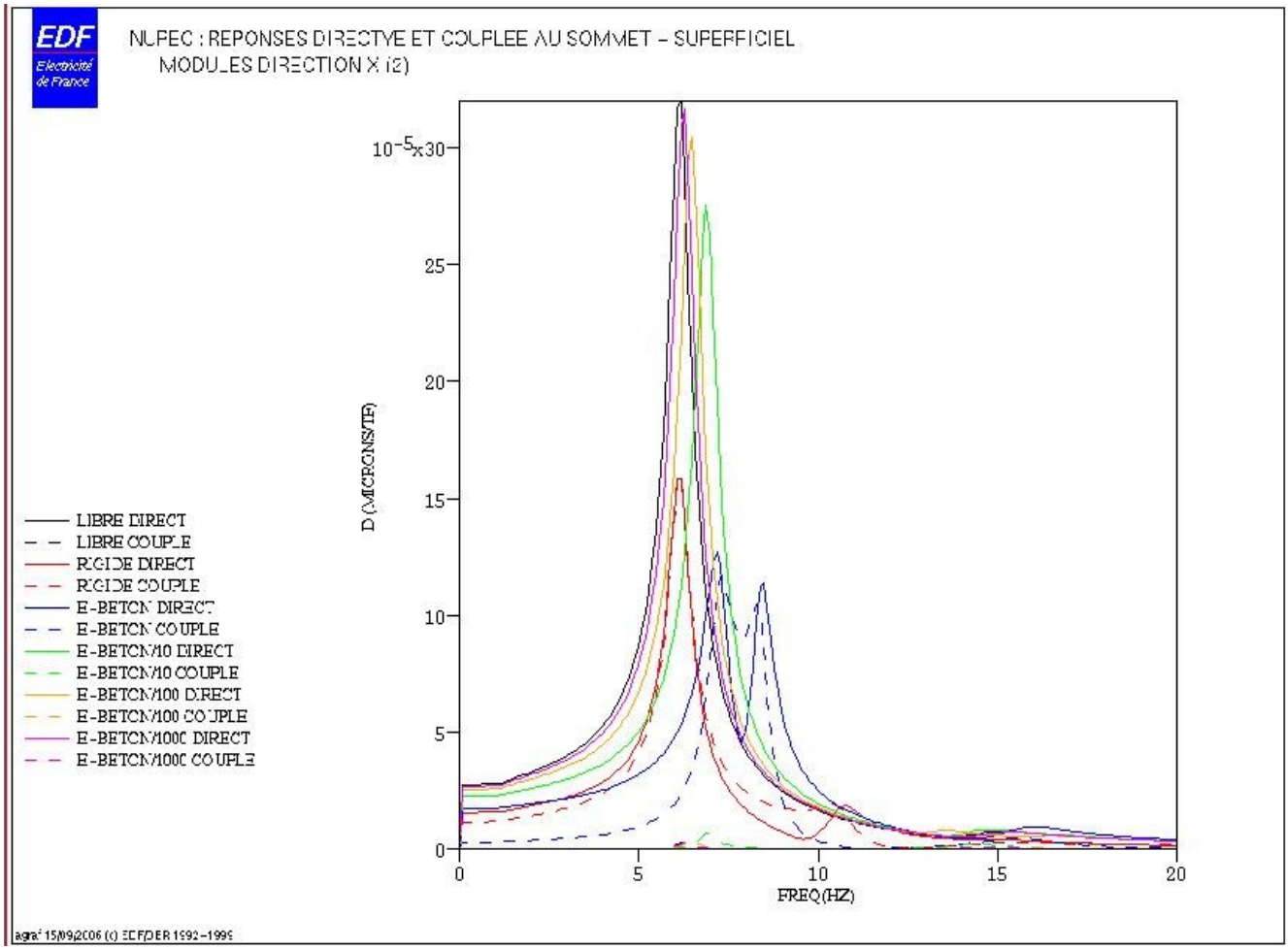

Figure 5-c: Comparison of the modules of the answers direct and coupled with the harmonic excitation between rigid case uncoupled and flexible case with reduction from the module of the foundation of connection in the direction X.

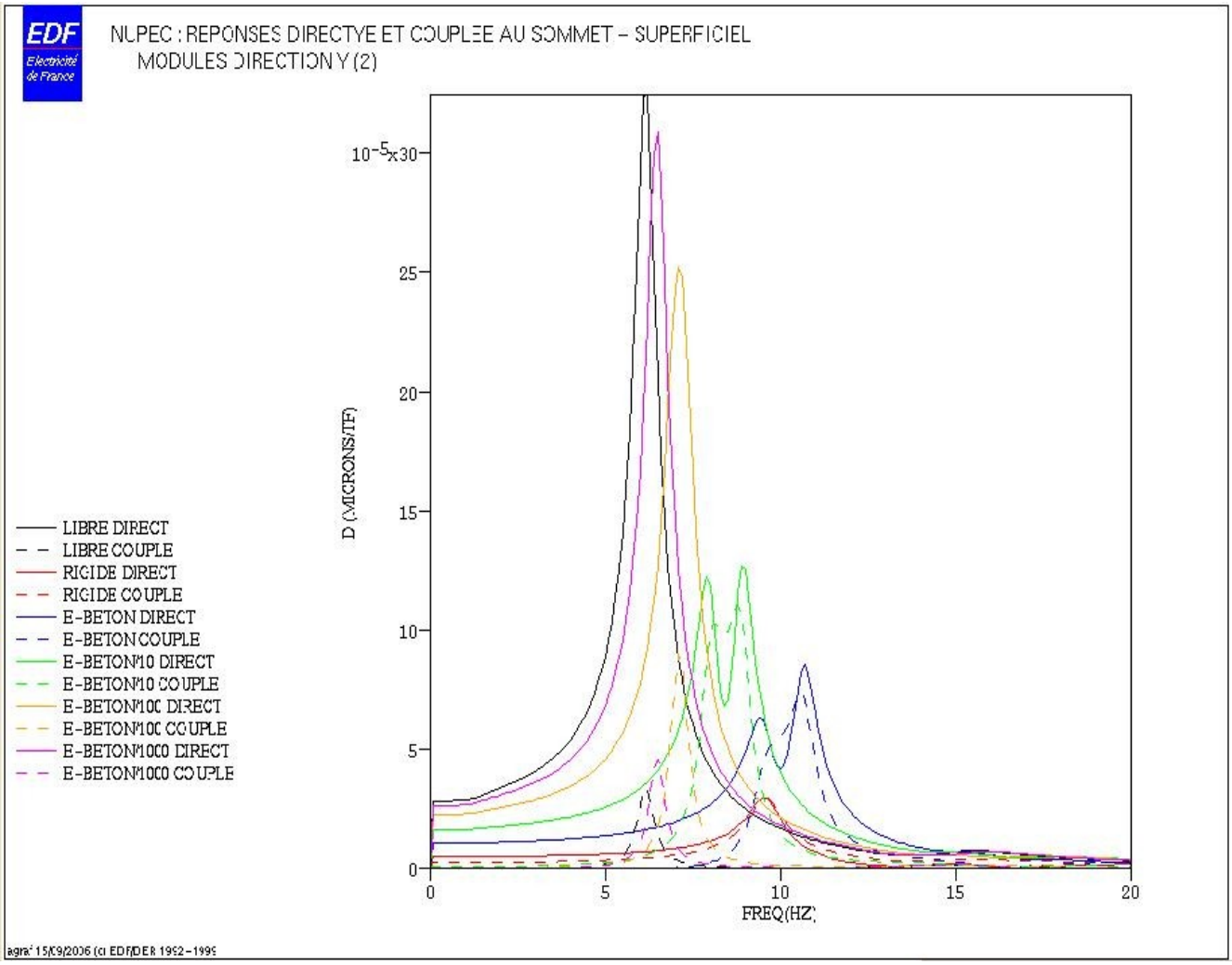

Figure 5-d: Comparison of the modules of the answers direct and coupled with the harmonic excitation between rigid case uncoupled and flexible case with reduction from the module of the foundation of connection in the direction Y.