SDLX104 - Implementation of the method of modal reduction in chaining MISS3D -*Code_Aster*

Summary:

This test of nonregression implements a calculation of interaction ground-structure carried out with the method of modal reduction thanks to the chaining *Code_Aster* - MISS3D by the frequential method of coupling on a model 3D of building resting on a laminated ground. One thus takes again the model and the loading of the case test MISS01.

Spectra of answer obtained starting from the model 3D of the building and using the chain *Code_Aster* - MISS3D are compared with those obtained by a calculation carried out with taking into account of all the constrained modes of interface (assumption of erasing flexible) constituting a result of reference.

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

- ground,
- the foundation,
- the building.

The geometry taken into account is that of a building extended on erasing single.

- Geometry of the model of the foundation

The foundation raft is cruciform, as shows it below it [Figure 1.1-a]:

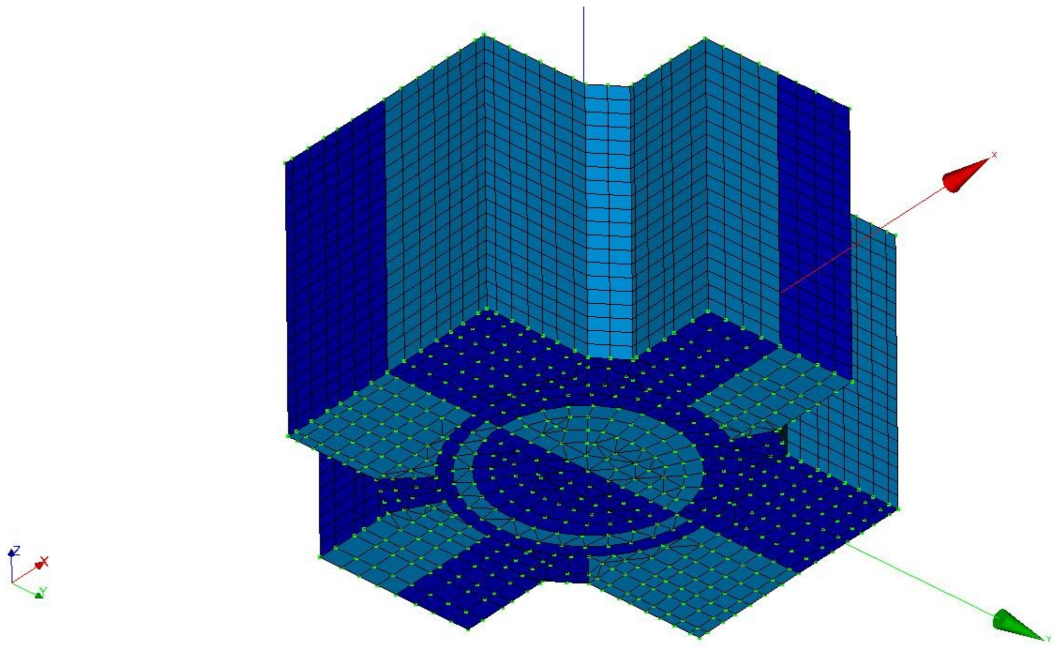

Figure 1.1-a: Foundation of the building

1.2 Properties of materials

An average laminated ground is considered whose characteristics are summarized in the table hereafter:

Sleep	**Thickness** (m)	$\rho(kg/m^3)$	ν	$E(MPa)$	β
Lay down 1	43.9	2150	0.40	4480	0.08
2 sleep	31.0	2070	0.45	1421	0,114
3 sleep	38.5	2150	0.45	1305	0.16
4 sleep	substratum	2400	0.45	6000	0.06

Table 1.2-1: Characteristics soil mechanics laminated

The foundation and the building are out of reinforced concretes, prestressed and rigid:

Material	$E(Pa)$	$\rho(kg/m^2)$	ν
armed	3.5 E10	0 - > 12500	0.2
prestressed	4.0 E10	2.5 E3	0.2
rigid	4.0 E11	0.	0.2

1.3 Boundary conditions and loadings mechanical

The foundation is regarded as rigid. This condition is ensured by a solid connection on the group of meshs of the foundation.

The seismic excitation of the structure is carried out by applying 3 accélérogrammes, such as:

Direction	**Accélérogramme**	**Normalizes**
X	`acc1.c2`	$0.1\,g$
Y	`acc2.c2`	$0.1\,g$
Z	`acc3.c2`	$0.06\,g$

Table 1.3-1: Seismic excitations

One thus gives here the accélérogramme (normalized to $0.1\mathrm{g}$) and the spectrum of each elementary excitation for a damping of 4%.

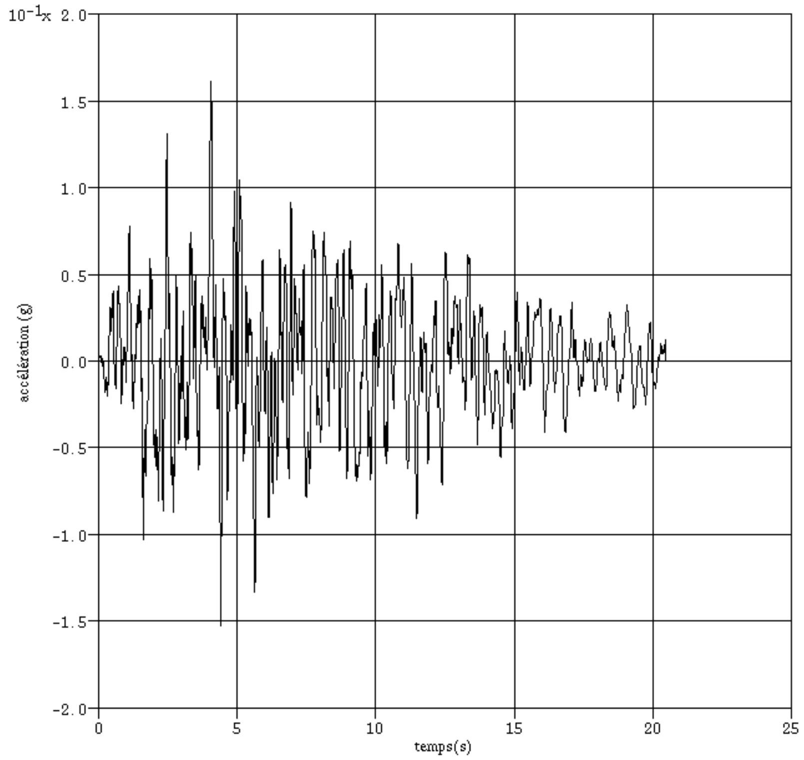

Figure 1.3-a: Accélérogramme `acc1.c2`

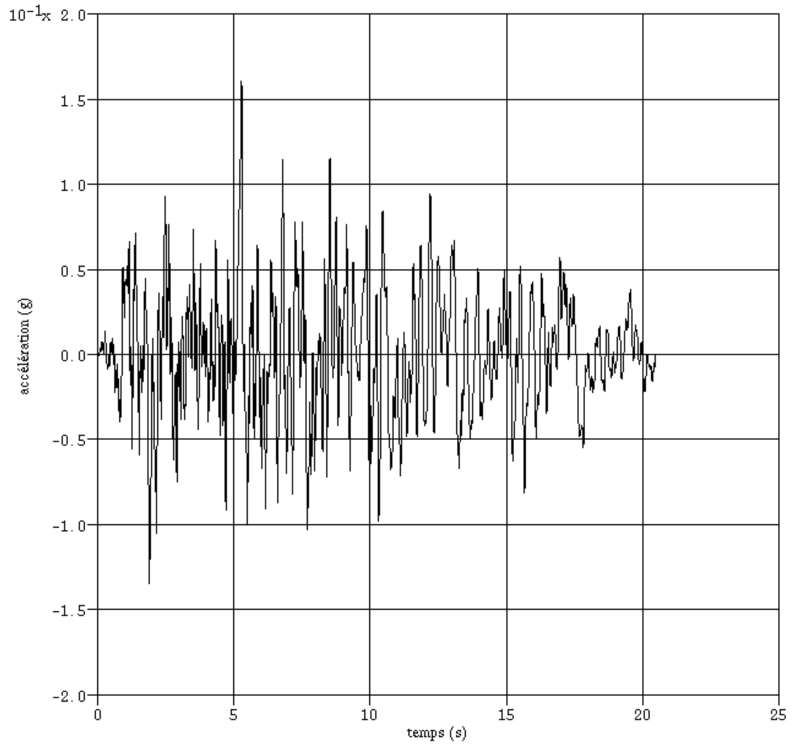

Figure 1.3-b: Accélérogramme `acc2.c2`

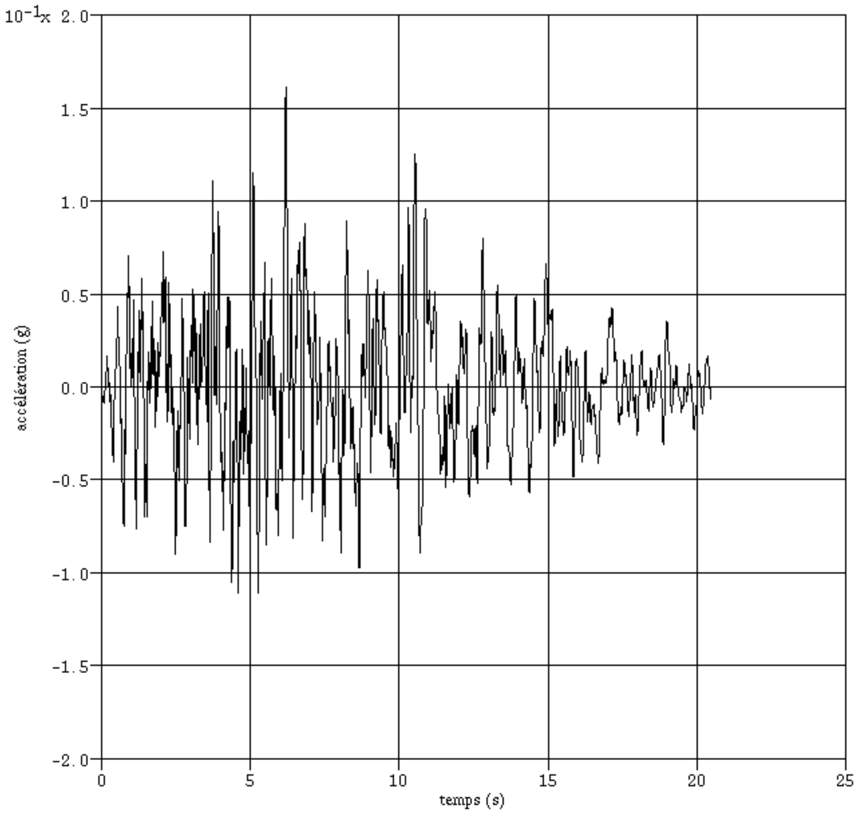

Figure 1.3-c: Accélérogramme `acc3.c2`

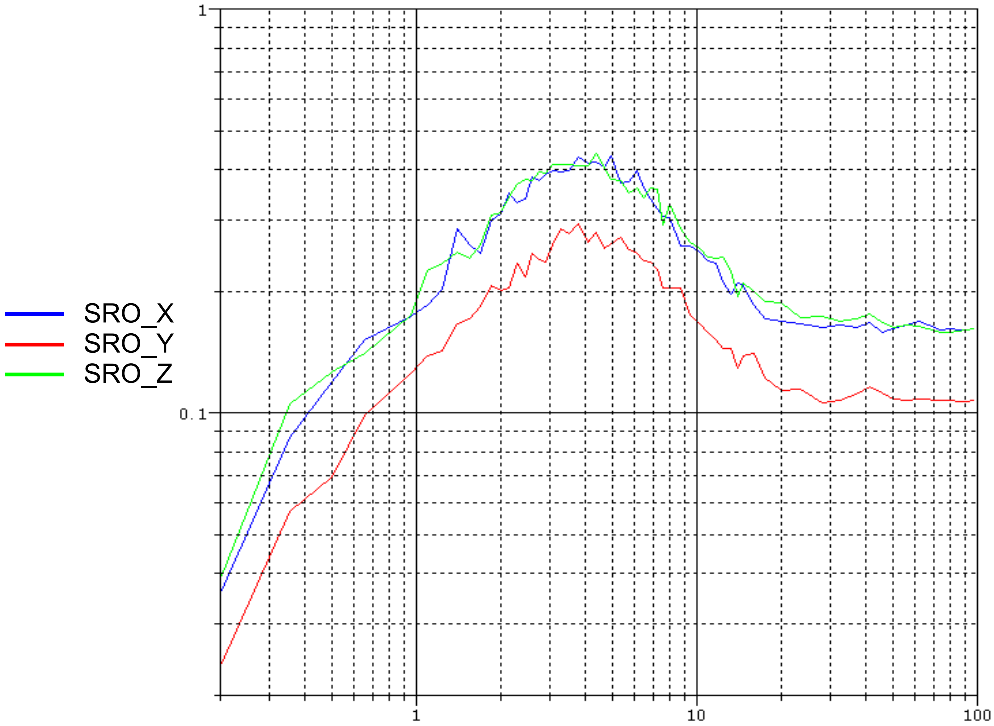

Figure 1.3-d: Spectra of the excitation

2 Reference solution

2.1 Method of calculating used for the reference solution

The method used for calculation on flexible foundation in interaction ground-structure (ISS) consists in considering only some selected modes of foundation

2.1.1 Principal stages of the method of modal reduction

For the calculation of ISS, MISS3D needs a base made up at the same time of worthless clean modes on the interface ground-structure and other nonworthless modes on this interface. This base corresponds to an interface of the type CRAIG_BAMPTON. For the first modes, one generally takes the clean modes of the structure obtained by blocking displacements on the interface (bases blocked) and for the seconds, one takes static the modes known as “constrained”, successively obtained by imposing a unit displacement of each degree of freedom of each node of the interface (the foundation).

The principle of the method put here in work consists in replacing the plethoric constrained static modes by clean modes of foundation of small number calculated on carpet of springs of ground and chosen according to an established criterion.

Several stages are necessary to conclude calculation.

2.1.2 Determination of the carpet of springs to be placed under the foundation.

The values of the stiffnesses of the springs equivalent on the laminated ground of the building are given through a calculation of the transfer transfer functions under harmonic request of module 1 at the time of the study with rigid foundation (*cf.* test SDLX101 [V2.05.101]).

One obtains the 6 values of total stiffness within the competence of the laminated ground: $Kx(N/m)$, $Ky(N/m)$, $Kz(N/m)$, $K\theta x(N.m)$, $K\theta y(N.m)$, $K\theta z(N.m)$. These stiffnesses, independent of the frequency, are distributed in proportion to surfaces of the elements around the nodes of the foundation thanks to the operand RIGI_PARASOL order AFFE_CARA_ELEM [U4.42.01] of *Code_Aster*.

2.1.3 The calculation of the dynamic modes of the structure

This calculation is carried out on basis embedded with the order CALC_MODES (one applies to all the nodes of the foundation the following boundary condition: $Dx=Dy=Dz=Drx=Dry=Drz=0$).

2.1.4 The calculation of the clean modes of foundation on carpet of springs

During the calculation of the clean modes of foundation on carpet of springs with the order CALC_MODES, one dissociates the modes with nonworthless displacements of the infrastructure (to erase) modes of the superstructure (buildings….) by considering that only the foundation raft is heavy. This is carried out while applying, with the elements not modelling the foundation, a material whose density is worthless. One avoids thus, during the construction of the modal base gathering the modes of foundation and dynamic of the structure, to twice consider the clean modes of the superstructure.

One enriches then the modal base established with [§ 2.1.3], via the order DEFI_BASE_MODALE, keyword RITZ, by the first calculated modes which all are of the modes of foundation since are rejected towards the high frequency all the modes of the superstructure.

2.1.5 Selection of the modes

While reducing considerably the number of constrained modes of foundation one can manage to find the solution in answer and frequency of resonance obtained with the preceding method implementing totality of the static modes and allowing a time-saver of substantial calculation.

One judges that the method of reduction is interesting, in term of time-saver, when the number of clean modes of foundation on carpet of spring is with most equal to the third amongst modes statics on flexible foundation (for this study, the method is interesting if the number of modes of foundation on carpet of spring is lower than approximately 500 modes).

To refine the selection of the modes, one can use the method recommended by E. Balmès **[bib2]** who consists in retaining twice only the modes of foundation giving of the Eigen frequencies of generalized modes lower than the cut-off frequency used during the calculation of the dynamic modes [Figure 2.1.5-a].

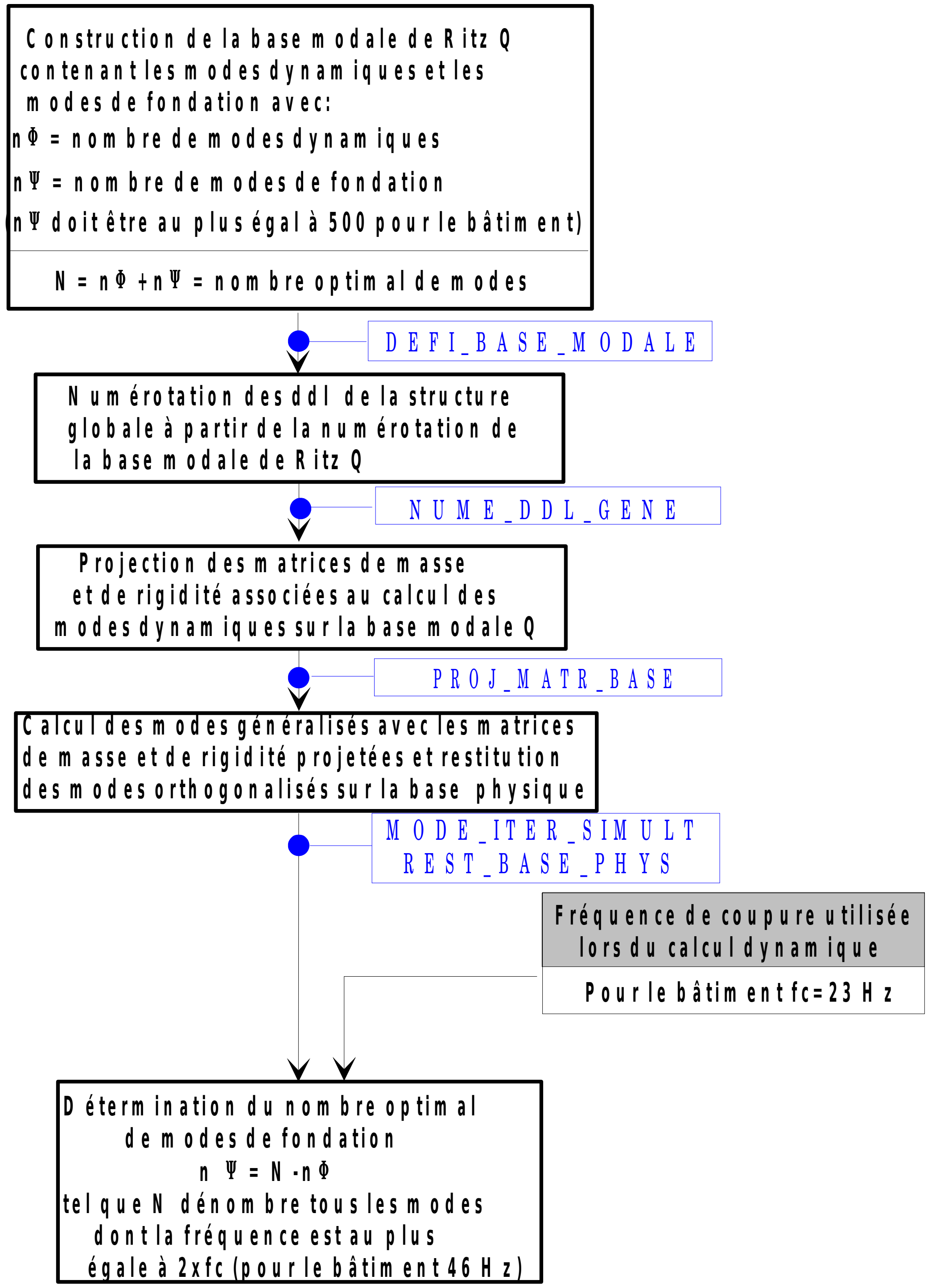

Figure 2.1.5-a: Optimization amongst modes of foundation

The course of complete calculation with reduction of the modes of foundation is done in the following way:

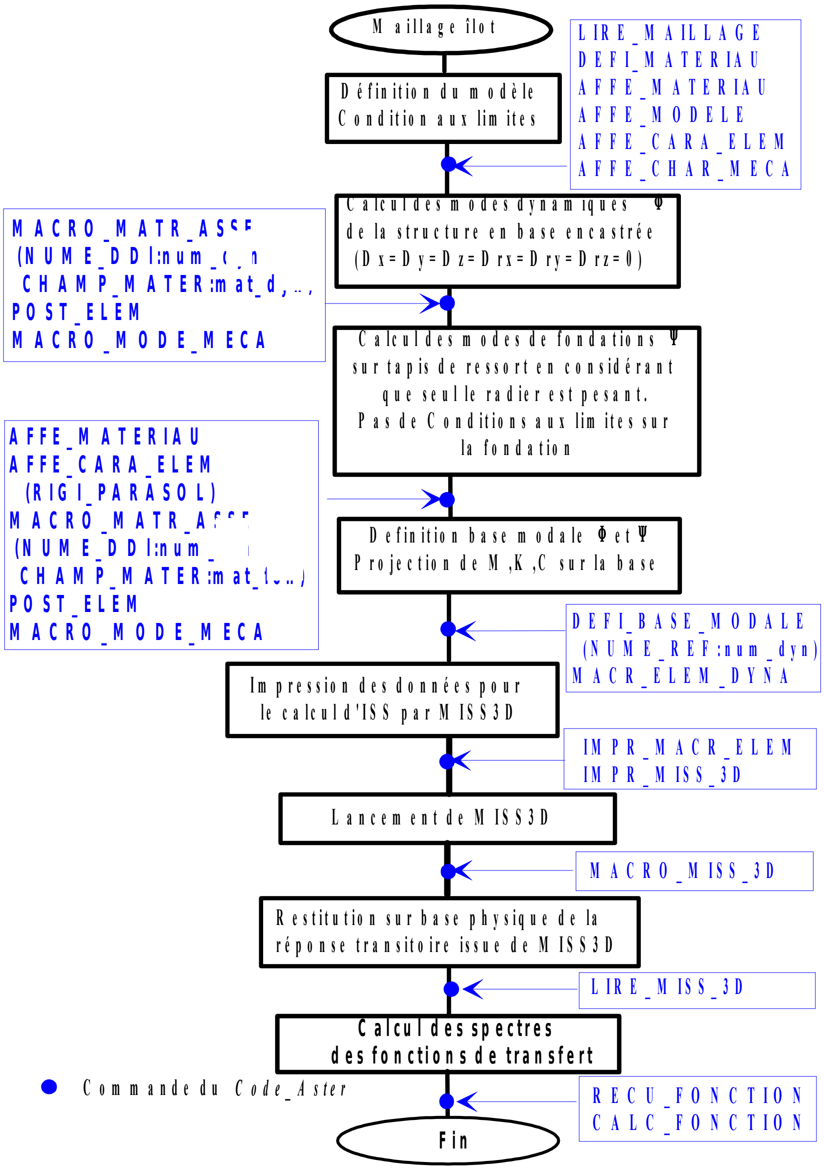

Figure 2.1.5-b: Synoptic of calculation with modes of foundation on carpet of springs

2.2 Results of reference

The spectra of floor were calculated in pseudo-acceleration with a damping of 4% in the horizontal directions X and Y at the top of the building.

For this level, one calculates the spectra on certain nodes of the grid. The final spectrum is obtained by taking the envelope of the directions X and Y. The values tested correspond to the peaks of this spectrum.

2.3 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. E. BALMES: “Of generalized interfaces uses dismantle of freedom in component mode synthesis” IMAC 1996

3 Modeling A

3.1 Characteristics of modeling

The foundation in the shape of cross:

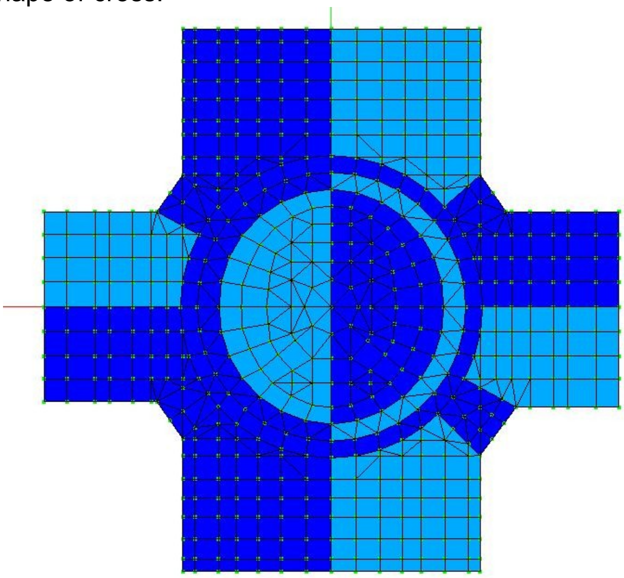

Figure 3.1-a: Grid of the foundation

Grid of the building

The model hollow 3D of the building consists of elements of plates:

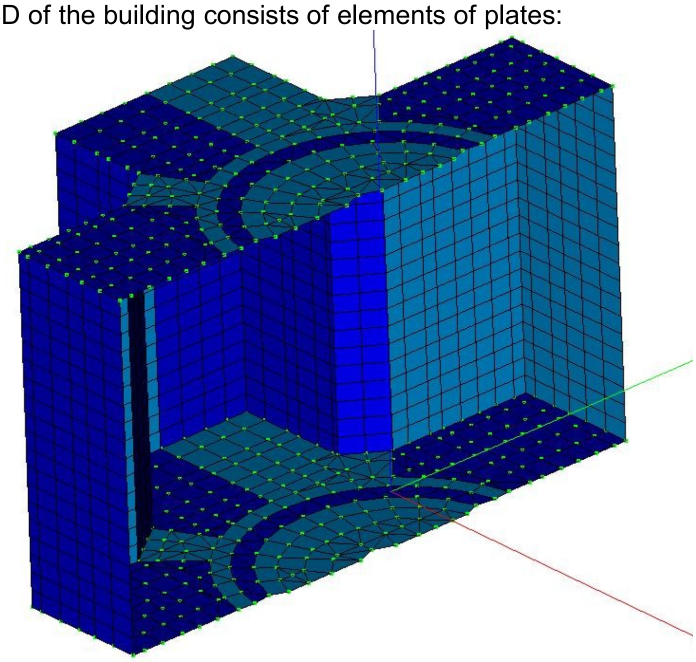

Figure 3.1-b: Representation out of cut of the grid of the building

3.2 Characteristics of the grid

The model is composed of 3,149 nodes and 3,432 elements plates.

4 Results of modeling A

4.1 Values tested

One tests the spectra for certain frequencies.

5 Summary of the results

The results of horizontal spectra obtained by the method of modal reduction at the top of the building are tested in not-regression.