

## SDLL112 – Seismic analysis of a multimedia beam (spectral response)

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### Summary

This test relates to the seismic analysis with the spectral method of a beam vertical, embedded at its base and articulated in two points of different altitude. The structure is subjected to an excitation provided in the shape of a spectrum of oscillators in pseudo-acceleration.

Via this problem, one tests modal combinations SRSS and CQC of the operator `COMB_SISM_MODAL` [U4.84.01], with taking into account or not of the neglected modes.

In addition, the operators are tested `CALC_MODES` [U4.52.02], `NORM_MODE` [U4.52.11], `MODE_STATIQUE` [U4.52.14], `DEFI_FONCTION` [U4.31.02] and `DEFI_NAPPE` [U4.31.03].

The validation consists with:

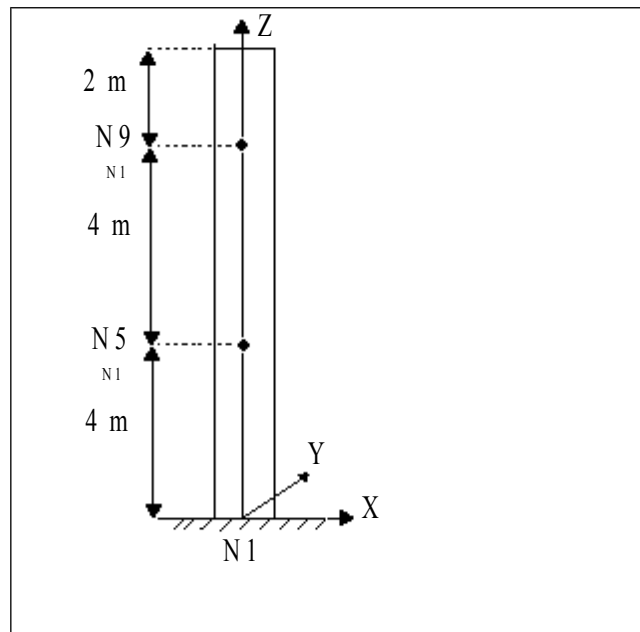
- to compare the results with those obtained using CASTEM 2000 (modeling A (3D) : mono-support combination CQC, multi-support excitation identical to the supports combination CQC);
- to find the answer mono-support by the way multi-support, in the case of excitations identical to the supports (modelings A (3D) and B (2D) ), combination CQC);
- to check the not-regression of the answer if there do not exist bench-mark data (different excitations to the supports).

The got results result in agreement with those from CASTEM 2000. In the case of excitations equal to the supports, the answer calculated in multi-support via the option 'CORRELATE' is identical to the answer calculated in mono-support.

## 1 Problem of reference

### 1.1 Geometry

The chimney is a vertical beam length  $10\text{ m}$ , embedded at its base and articulated in two points of altitude  $4\text{ m}$  and  $8\text{ m}$ .



Cross section of the beam:

Surface:  $A = 3.4390 \cdot 10^{-3} \text{ m}^2$   
 Moments of inertia:  $I_y = 1.3770 \cdot 10^{-5} \text{ m}^4$   
 $I_z = 1.3770 \cdot 10^{-5} \text{ m}^4$   
 $J_x = 2.7540 \cdot 10^{-5} \text{ m}^4$

### 1.2 Material properties

Beam	Young modulus	$E = 1.658 \cdot 10^{11} \text{ Pa}$
	density	$\rho = 1.3404106 \cdot 10^4 \text{ kg/m}^3$
	Poisson's ratio	$\nu = 0,3$

## 1.3 Boundary conditions and loadings

Modelisation A (3D)

Not *N1* embedded:  $DX = DY = DZ = DRX = DRY = DRZ = 0$

Points *N5* and *N9* attaches:  $DX = DY = 0$

Spectra of horizontal oscillators in acceleration applied to the points *N1*, *N5* and *N9* in the directions (*x*) and (*x* and *y*).

Modeling B (2D plan *XZ*)

Problem plan *XZ* :  $DY = DRX = DRZ = 0$

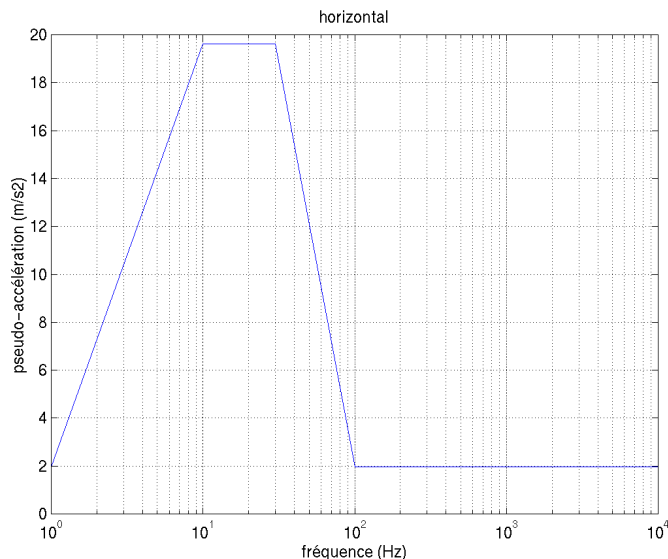
Not *N1* embedded:  $DX = DZ = DRY = 0$

Points *N5* and *N9* attaches:  $DX = 0$

Spectra of horizontal oscillators in acceleration applied to the points *N1*, *N5* and *N9* in the direction (*x*).

Identical spectra of values for 3 depreciation 0,5%, 1% and 1,5% .

Frequency ( Hz )	Pseudo-acceleration ( $m.s^{-2}$ ) in <i>x</i>	Pseudo-acceleration ( $m.s^{-2}$ ) in <i>y</i>
1	1,962	1,962
10	19.62	19.62
30	19.62	19.62
100	1,962	1,962
10000	1,962	1,962



For calculation, one uses a reduced damping of 3%, with an interpolation (LOG LOG) in frequency and (FLAX LOG) in damping.

Case multi-support with different excitations:

not *N1* : excitation  $\times 1$

not *N5* : excitation  $\times 1.5$

not *N9* : excitation  $\times 2$

## 1.4 Initial conditions

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Without object for the spectral analysis

## 2 Reference solution

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### 2.1 Method of calculating used for the reference solution

Comparison between the results and those obtained using CASTEM 2000 (modeling With (3D): myO-support combination CQC and SRSS, multi-support excitation identical to the supports combination CQC);

If not, the validation consists with:

- to find the answer mono-support by the way multi-support, in the case of excitations identical to the supports (modelings With (3D) ET B ( 2D ), combination CQC);
- to check the not-regression of the answer if there do not exist bench-mark data (modelings A and B, different excitations with the supports).

### 2.2 Results of reference

Results got using CASTEM 2000: displacements with the nodes  $N3$  ,  $N7$  and  $N11$  for the following cases:  
modeling With (3D)  
mono-support, combination CQC  
multi-support excitation identical to the supports combination CQC.

### 2.3 Bibliographical references

Pas de reference published.

## 3 Modeling A

### 3.1 Characteristics of modeling

Modeling is three-dimensional. The beam is broken up into 10 elements of modeling `POU_D_E`.

### 3.2 Characteristics of the grid

Many nodes: 11

Many meshes and types: 10 meshes of the type `SEG2 (POU_D_E)`

The group of nodes `encastre` the node contains `N1` ( $dx = dy = dz = drx = dry = drz = 0$ ).

The group of nodes `attache` contains the nodes `N5` and `N9` ( $dx = dy = 0$ ).

### 3.3 Parameters of modeling

Answer in mono-support on the first 10 modes, excitation according to  $x$ , without static correction (combination of modal answers CQC)

Answer in mono-support on the first 10 modes, excitation according to  $x$ , with static correction (combination of modal answers CQC)

Answer in multi-support on the first 10 modes with identical excitation according to  $x$  in all the supports, without static correction and displacements of anchoring (combination of modal answers CQC)

Answer in multi-support on the first 10 modes with excitations in  $x$  and  $y$  different and correlated with the supports, with static correction (combination of modal answers CQC)

Quadratic combination of the directional answers (**QUAD**)

Linear combination of the loading cases.

### 3.4 Sizes tested and results

#### 3.4.1 Excitation mono-support according to X

##### 3.4.1.1 Modal analysis

```
--- VALUES OF THE SPECTRUM ---
MODE      FREQUENCY      DAMPING      DIR      SPECTRUM
1-2       1.54569D+01      3.00000D-02  X        1.96200D+01
3-4       3.35823D+01      3.00000D-02  X        1.58128D+01
5-6       4.73076D+01      3.00000D-02  X        8.21089D+00
7         5.45850D+01      3.00000D-02  X        6.24517D+00
8         8.80156D+01      3.00000D-02  X        2.50454D+00
9-10      1.01614D+02      3.00000D-02  X        1.96200D+00
```

TOTAL MASS OF THE STRUCTURE: 4.60967D+02

MODAL MASS EFFECTIVE CUMULEE:

DIRECTION: X, OFFICE PLURALITY: 3.09868D+02, IS 67.221%

##### 3.4.1.2 Seismic analysis in mono-support

Size: 'depl' NOM\_MODE: ('to dir' 'X') NOM\_CMP: 'dx'

Combination 'CQC' without static correction

Identification	Reference	Aster	% difference
Displacements according to $x$	CASTEM 2000	Aster 9.02.11	
N3 NODE	1.78952 <sup>E</sup> -04	1.784933 <sup>E</sup> -04	-0,256
N7 NODE	3.29499 <sup>E</sup> -04	3.292709 <sup>E</sup> -04	-0,069
N11 NODE	1.09032 <sup>E</sup> -03	1.089717 <sup>E</sup> -03	-0,055
Absolute acceleration	Aster 5.3.13	Aster 9.02.11	
N1 NODE	1.96200 <sup>E</sup> +00	1.96200 <sup>E</sup> +00	0.00
N5 NODE	1.96200 <sup>E</sup> +00	1.96200 <sup>E</sup> +00	0.00
N9 NODE	1.96200E+00	1.96200E+00	0.00
Nodal reaction	Aster 5.3.13	Aster 9.02.11	
N1 NODE	6.696036 <sup>E</sup> +02	6.696036 <sup>E</sup> +02	1.6 <sup>E</sup> -06
N5 NODE	1.164223 <sup>E</sup> +03	1.164223 <sup>E</sup> +03	-2.7 <sup>E</sup> -05
N9 NODE	9.281995 <sup>E</sup> +02	9.281995 <sup>E</sup> +02	-2.8 <sup>E</sup> -06

Combinaison CQC with static correction

Identification	Reference	Aster	% difference
Displacements according to $x$	CASTEM 2000	Aster 9.02.11	
N3 NODE	1.78952 <sup>E</sup> -04	1.784937 <sup>E</sup> -04	-0,256
N7 NODE	3.29499 <sup>E</sup> -04	3.292709 <sup>E</sup> -04	-0,069
N11 NODE	1.09032 <sup>E</sup> -03	1.089718 <sup>E</sup> -03	-0,055
Absolute acceleration	Aster 5.3.13	Aster 9.02.11	
N1 NODE	1.96200 <sup>E</sup> +00	1.96200 <sup>E</sup> +00	0.00
N5 NODE	1.96200 <sup>E</sup> +00	1.96200 <sup>E</sup> +00	0.00
N9 NODE	1.96200E+00	1.96200E+00	0.00
Nodal reaction	Aster 5.3.13	Aster 9.02.11	
N1 NODE	6.716683 <sup>E</sup> +02	6.716683 <sup>E</sup> +02	-2.3 <sup>E</sup> -07
N5 NODE	1.169727 <sup>E</sup> +03	1.169727 <sup>E</sup> +03	-9.9 <sup>E</sup> -06
N9 NODE	9.373269 <sup>E</sup> +02	9.373269 <sup>E</sup> +02	-2.6 <sup>E</sup> -06

## 3.4.2 Excitation multi-support according to X

### 3.4.2.1 Modal analysis

--- VALUES OF THE SPECTRUM ---

MODE	FREQUENCY	DAMPING	DIR	SUPPORT	SPECTRUM	
1-2	1.54569D+01	3.00000D-02		X	N1 N5 N9	1.96200D+01
3-4	3.35823D+01	3.00000D-02		X	N1 N5 N9	1.58128D+01
5-6	4.73076D+01	3.00000D-02		X	N1 N5 N9	8.21089D+00
7	5.45850D+01	3.00000D-02		X	N1 N5 N9	6.24517D+00
8	8.80156D+01	3.00000D-02		X	N1 N5 N9	2.50454D+00
9-10	1.01614D+02	3.00000D-02		X	N1 N5 N9	1.96200D+00

TOTAL MASS OF THE STRUCTURE: 4.60967D+02

MODAL MASS EFFECTIVE CUMULEE:

DIRECTION: X, OFFICE PLURALITY: 3.09868D+02, IS 67.221%

### 3.4.2.2 Seismic analysis in multi-support (with excitations identical to the supports, without static correction, displacements of anchorings)

Combination 'CQC' without static correction

Identification	Reference	Aster	% difference
Displacements according to $x$	CASTEM 2000	Aster 9.02.21	
N3 NODE	1.78952 <sup>E</sup> -04	1.784933 <sup>E</sup> -04	-0,256
N7 NODE	3.29499 <sup>E</sup> -04	3.292709 <sup>E</sup> -04	-0,069
N11 NODE	1.09032 <sup>E</sup> -03	1.089717 <sup>E</sup> -03	-0,055
Absolute acceleration	Aster 9.02.11	Aster 9.02.21	
N1 NODE	1.96200 <sup>E</sup> +00	1.96200 <sup>E</sup> +00	0.00
N5 NODE	1.96200 <sup>E</sup> +00	1.96200 <sup>E</sup> +00	0.00
N9 NODE	1.96200E+00	1.96200E+00	0.00
Nodal reaction	Aster 9.02.11	Aster 9.02.21	
N1 NODE	6.696036 <sup>E</sup> +02	6.696036 <sup>E</sup> +02	1.6E-06
N5 NODE	1.164223 <sup>E</sup> +03	1.164223 <sup>E</sup> +03	-2.7E-05
N9 NODE	9.281995 <sup>E</sup> +02	9.281995 <sup>E</sup> +02	-2.8E-06



### 3.4.3 Excitation multi-support according to X and there

#### 3.4.3.1 Modal analysis

--- VALUES OF THE SPECTRUM ---

MODE	FREQUENCY	DAMPING	DIR	SUPPORT	SPECTRUM		
1-2	1.54569D+01	3.00000D-02			X Y	N1	1.96200D+01
						N5	2.94300D+01
						N9	3.92400D+01
3-4	3.35823D+01	3.00000D-02			X Y	N1	1.58128D+01
						N5	2.37192D+01
						N9	3.16256D+01
5	4.73076D+01	3.00000D-02			X Y	N1	8.21089D+00
						N5	1.23163D+01
						N9	1.64218D+01
6	4.73076D+01	3.00000D-02			X Y	N1	8.21089D+00
						N5	1.23163D+01
						N9	1.64218D+01
7	5.45850D+01	3.00000D-02			X Y	N1	6.24517D+00
						N5	9.36775D+00
						N9	1.24903D+01
8	8.80156D+01	3.00000D-02			X Y	N1	2.50454D+00
						N5	3.75681D+00
						N9	5.00908D+00
9-10	1.01614D+02	3.00000D-02			X Y	N1	1.96200D+00
						N5	2.94300D+00
						N9	3.92400D+00

TOTAL MASS OF THE STRUCTURE: 4.60967D+02

MODAL MASS EFFECTIVE CUMULEE:

DIRECTION: X, OFFICE PLURALITY: 3.09868D+02, IS 67.221%  
 DIRECTION: Y, OFFICE PLURALITY: 3.09868D+02, IS 67.221%

#### 3.4.3.2 Seismic analysis in multi-support (with correlated different excitations, static correction, displacements of anchorings)

Identical excitations in the two directions  $x$  and  $y$   
 Combination of modes 'CQC'  
 Combination of the loading cases: 'FLAX'  
 Combination of directions 'QUAD'

Identification	Reference	Aster	% difference
<b>Directional answer according to <math>x</math></b>			
Displacements according to $x$		Aster 9.02.11	Aster 9.02.21
N3 NODE	5.8865524E-04	5.8865524E-04	4.1 <sup>E</sup> -07
N5 NODE	1.0000000E-03	1.0000000E-03	0.00
N7 NODE	1.1592562E-03	1.1592562E-03	4.3 <sup>E</sup> -06
N9 NODE	1.0000000E-03	1.0000000E-03	0.00
N11 NODE	3.1715622E-03	3.1715622E-03	8.1 <sup>E</sup> -07
Absolute acceleration		Aster 9.02.11	Aster 9.02.21
N1 NODE	1.96200 <sup>E</sup> +00	1.96200 <sup>E</sup> +00	0.00
N5 NODE	1.96200 <sup>E</sup> +00	1.96200 <sup>E</sup> +00	0.00
N9 NODE	1.96200E+00	1.96200E+00	0.00
Nodal reaction		Aster 9.02.11	Aster 9.02.21
N1 NODE	1.2923446E+03	1.2923446E+03	-2.9E-06

N5 NODE	1.9925394E+03	1.9925394E+03	1.6E-06
N9 NODE	2.0643776E+03	2.0643776E+03	2.2 <sup>E</sup> -06
<b>Directional answer according to <math>y</math></b>			
Displacements according to $y$		Aster 9.02.11	Aster 9.02.21
N3 NODE	5.8865524E-04	5.8865524E-04	4.1 <sup>E</sup> -07
N5 NODE	1.0000000E-03	1.0000000E-03	0.00
N7 NODE	1.1592562E-03	1.1592562E-03	4.3 <sup>E</sup> -06
N9 NODE	1.0000000E-03	1.0000000E-03	0.00
N11 NODE	3.1715622E-03	3.1715622E-03	8.1 <sup>E</sup> -07
Absolute acceleration		Aster 9.02.11	Aster 9.02.21
N1 NODE	1.96200 <sup>E</sup> +00	1.96200 <sup>E</sup> +00	0.00
N5 NODE	1.96200 <sup>E</sup> +00	1.96200 <sup>E</sup> +00	0.00
N9 NODE	1.96200E+00	1.96200E+00	0.00
<b>Total answer in displacements</b>			
Component according to $x$			
N3 NODE	5.8865524E-04	5.8865524E-04	4.1 <sup>E</sup> -07
N5 NODE	1.0000000E-03	1.0000000E-03	0.00
N7 NODE	1.1592562E-03	1.1592562E-03	4.3 <sup>E</sup> -06
N9 NODE	1.0000000E-03	1.0000000E-03	0.00
N11 NODE	3.1715622E-03	3.1715622E-03	8.1 <sup>E</sup> -07
Component according to $y$			
N3 NODE	5.8865524E-04	5.8865524E-04	4.1 <sup>E</sup> -07
N5 NODE	1.0000000E-03	1.0000000E-03	0.00
N7 NODE	1.1592562E-03	1.1592562E-03	4.3 <sup>E</sup> -06
N9 NODE	1.0000000E-03	1.0000000E-03	0.00
N11 NODE	3.1715622E-03	3.1715622E-03	8.1 <sup>E</sup> -07

## 3.5 Remarks

The results with excitations equal to the supports are identical via two modelings mono-support and multi-support.

## 4 Modeling B

### 4.1 Characteristics of modeling

Modeling is two-dimensional. The beam is broken up into 10 elements of modeling `POU_D_E`.

### 4.2 Characteristics of the grid

Many nodes: 11

Many meshes and types: 10 meshes of the type `SEG2 (POU_D_E)`

Problem plan: for all the nodes:  $dy=0$  ;  $drx=drz=0$

The group of nodes *encastre* the node contains *N1* ( $dx=dz=dy=0$ ).

The group of nodes *attache* contains the nodes *N5* and *N9* ( $dx=0$ ).

### 4.3 Parameters of modeling

Answer in mono-support on the first 5 modes, excitation according to  $x$ , without static correction (combination of modal answers CQC and SRSS)

Answer in mono-support on the first 5 modes, excitation according to  $x$ , with static correction (combination of modal answers CQC)

Answer in multi-support on the first 5 modes with identical excitation according to  $x$  in all the supports, without static correction and displacements of anchoring (combination of modal answers CQC)

Answer in multi-support on the first 5 modes with excitations in  $x$  different and correlated with the supports, with static correction (combination of modal answers CQC)

Linear combination of the loading cases.

### 4.4 Sizes tested and results

#### 4.4.1 Excitation mono-support according to X

##### 4.4.1.1 Modal analysis

--- VALUES OF THE SPECTRUM ---

MODE	FREQUENCY	DAMPING	DIR	SPECTRUM
1	1.54569D+01	3.00000D-02	X	1.96200D+01
2	3.35823D+01	3.00000D-02	X	1.58128D+01
3	4.73076D+01	3.00000D-02	X	8.21089D+00
4	8.80156D+01	3.00000D-02	X	2.50454D+00
5	1.01614D+02	3.00000D-02	X	1.96200D+00

TOTAL MASS OF THE STRUCTURE: 4.60967D+02

MODAL MASS EFFECTIVE CUMULEE:

DIRECTION: X, OFFICE PLURALITY: 3.09868D+02, IS 67.221%

##### 4.4.1.2 Seismic analysis in mono-support

```
NOM_CHAMP : 'depl'           NOEUD_CMP : ('to dir' 'X')   NOM_CMP : 'dx'
NOM_CHAMP : 'acce_absolu'    NOEUD_CMP : ('to dir' 'X')   NOM_CMP : 'dx'
NOM_CHAMP : 'reac_noda'     NOEUD_CMP : ('to dir' 'X')   NOM_CMP : 'dx'
```

Combination 'CQC' without static correction

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Identification	Reference	Aster	% difference
Displacements according to $x$	Aster 5.3.13	Aster 9.02.21	
N3 NODE	1.78952 <sup>E</sup> -04	1.784933 <sup>E</sup> -04	-0,256
N7 NODE	3.29499 <sup>E</sup> -04	3.292709 <sup>E</sup> -04	-0,069
N11 NODE	1.09032 <sup>E</sup> -03	1.089717 <sup>E</sup> -03	-0,055
Absolute acceleration	Aster 5.3.13	Aster 9.02.21	
N1 NODE	1.96200 <sup>E</sup> +00	1.96200 <sup>E</sup> +00	0.00
N5 NODE	1.96200 <sup>E</sup> +00	1.96200 <sup>E</sup> +00	0.00
N9 NODE	1.96200E+00	1.96200E+00	0.00
Nodal reaction	Aster 5.3.13	Aster 9.02.21	
N1 NODE	6.696036 <sup>E</sup> +02	6.696036 <sup>E</sup> +02	1.6 <sup>E</sup> -06
N5 NODE	1.164223 <sup>E</sup> +03	1.164223 <sup>E</sup> +03	-2.7 <sup>E</sup> -05
N9 NODE	9.281995 <sup>E</sup> +02	9.281995 <sup>E</sup> +02	-2.8 <sup>E</sup> -06

Combination CQC with static correction

Identification	Reference	Aster	% difference
Displacements according to $x$	Aster 5.3.13	Aster 9.02.21	
N3 NODE	1.78952 <sup>E</sup> -04	1.784937 <sup>E</sup> -04	-0,256
N7 NODE	3.29499 <sup>E</sup> -04	3.292709 <sup>E</sup> -04	-0,069
N11 NODE	1.09032 <sup>E</sup> -03	1.089718 <sup>E</sup> -03	-0,055
Absolute acceleration	Aster 5.3.13	Aster 9.02.21	
N1 NODE	1.96200 <sup>E</sup> +00	1.96200 <sup>E</sup> +00	0.00
N5 NODE	1.96200 <sup>E</sup> +00	1.96200 <sup>E</sup> +00	0.00
N9 NODE	1.96200E+00	1.96200E+00	0.00
Nodal reaction	Aster 5.3.13	Aster 9.02.21	
N1 NODE	6.716683 <sup>E</sup> +02	6.716683 <sup>E</sup> +02	-2.3 <sup>E</sup> -07
N5 NODE	1.169727 <sup>E</sup> +03	1.169727 <sup>E</sup> +03	-9.9 <sup>E</sup> -06
N9 NODE	9.373269 <sup>E</sup> +02	9.373269 <sup>E</sup> +02	-2.6 <sup>E</sup> -06

Combination 'SRSS' without static correction

Identification	Reference	Aster	% difference
Displacements according to $x$	Aster 9.02.18	Aster 9.02.21	
N3 NODE	1.804848E-04	1.804848E-04	-1.1E-05
N7 NODE	3.290407E-04	3.290407E-04	4.9E-06
N11 NODE	1.088706E-03	1.088706E-03	-9.2 <sup>E</sup> -06
Absolute acceleration	Aster 9.02.18	Aster 9.02.21	
N1 NODE	1.96200 <sup>E</sup> +00	1.96200 <sup>E</sup> +00	0.00
N5 NODE	1.96200 <sup>E</sup> +00	1.96200 <sup>E</sup> +00	0.00
N9 NODE	1.96200E+00	1.96200E+00	0.00
Nodal reaction	Aster 9.02.18	Aster 9.02.21	
N1 NODE	6.762012E+02	6.762012E+02	6.6E-06
N5 NODE	1.164525E+03	1.164525E+03	-2.6E-06
N9 NODE	9.172971E+02	9.172971E+02	4.0 <sup>E</sup> -06

## 4.4.2 Excitation multi-support according to X

### 4.4.2.1 Modal analysis

--- VALUES OF THE SPECTRUM ---

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MODE	FREQUENCY	DAMPING	DIR	SUPPORT	SPECTRUM	
1	1.54569D+01	3.00000D-02		X	N1 N5 N9	1.96200D+01
2	3.35823D+01	3.00000D-02		X	N1 N5 N9	1.58128D+01
3	4.73076D+01	3.00000D-02		X	N1 N5 N9	8.21089D+00
4	8.80156D+01	3.00000D-02		X	N1 N5 N9	2.50454D+00
5	1.01614D+02	3.00000D-02		X	N1 N5 N9	1.96200D+00

TOTAL MASS OF THE STRUCTURE: 4.60967D+02

MODAL MASS EFFECTIVE CUMULEE:

#### 4.4.2.2 Seismic analysis in multi-support (with excitations identical to the supports, without static correction, displacements of anchorings)

NOM\_CHAMP: 'depl'                      NOEUD\_CMP: ('to dir' 'X')                      NOM\_CMP: 'dx'  
 NOM\_CHAMP: 'acce\_absolu'              NOEUD\_CMP: ('to dir' 'X')                      NOM\_CMP: 'dx'  
 NOM\_CHAMP: 'reac\_noda'                NOEUD\_CMP: ('to dir' 'X')                      NOM\_CMP: 'dx'

Combination 'CQC' without static correction

Identification	Reference	Aster	% difference
<b>Displacements according to <math>x</math></b>			
	Aster 9.02.18	Aster 9.02.21	
N3 NODE	1.78952 <sup>E</sup> -04	1.784933 <sup>E</sup> -04	-7.3E-06
N7 NODE	3.29499 <sup>E</sup> -04	3.292709 <sup>E</sup> -04	-8.8E-06
N11 NODE	1.09032 <sup>E</sup> -03	1.089717 <sup>E</sup> -03	4.0E-05
<b>Absolute acceleration</b>			
	Aster 9.02.18	Aster 9.02.21	
N1 NODE	1.96200 <sup>E</sup> +00	1.96200 <sup>E</sup> +00	0.00
N5 NODE	1.96200 <sup>E</sup> +00	1.96200 <sup>E</sup> +00	0.00
N9 NODE	1.96200E+00	1.96200E+00	0.00
<b>Nodal reaction</b>			
	Aster 9.02.18	Aster 9.02.21	
N1 NODE	6.696036 <sup>E</sup> +02	6.696036 <sup>E</sup> +02	1.6E-06
N5 NODE	1.164223 <sup>E</sup> +03	1.164223 <sup>E</sup> +03	-2.7E-05
N9 NODE	9.281995 <sup>E</sup> +02	9.281995 <sup>E</sup> +02	-2.8E-06

#### 4.4.2.3 Seismic analysis in multi-support (with correlated different excitations, static correction, displacements of anchorings)

NOM\_CHAMP: 'depl'                      NOEUD\_CMP: ('to dir' 'X')                      NOM\_CMP: 'dx'  
 NOM\_CHAMP: 'depl'                      NOEUD\_CMP: ('to dir' 'there')                      NOM\_CMP: 'Dy'  
 NOM\_CHAMP: 'acce\_absolu'              NOEUD\_CMP: ('to dir' 'X')                      NOM\_CMP: 'dx'  
 NOM\_CHAMP: 'reac\_noda'                NOEUD\_CMP: ('to dir' 'X')                      NOM\_CMP: 'dx'  
 NOM\_CHAMP: 'depl'                      NOEUD\_CMP: ('to dir' 'X')                      NOM\_CMP: 'combi' 'quad'  
 NOM\_CHAMP: 'depl'                      NOEUD\_CMP: ('to dir' 'there')                      NOM\_CMP: 'combi' 'quad'

Combination of modes 'CQC'

Combination of the loading cases: 'FLAX'

Identification	Reference	Aster	% difference
<b>Answer according to <math>x</math></b>			
<b>Displacements according to <math>x</math></b>			
	Aster 9.02.18	Aster 9.02.21	
N3 NODE	5.8865524E-04	5.8865524E-04	4.1 <sup>E</sup> -07
N5 NODE	1.0000000E-03	1.0000000E-03	0.00
N7 NODE	1.1592562E-03	1.1592562E-03	4.3 <sup>E</sup> -06

N9 NODE	1.0000000E-03	1.0000000E-03	0.00
N11 NODE	3.1715622E-03	3.1715622E-03	8.1 <sup>E</sup> -07
Absolute acceleration	Aster 9.02.18	Aster 9.02.21	
N1 NODE	1.96200 <sup>E</sup> +00	1.96200 <sup>E</sup> +00	0.00
N5 NODE	1.96200 <sup>E</sup> +00	1.96200 <sup>E</sup> +00	0.00
N9 NODE	1.96200E+00	1.96200E+00	0.00
Nodal reaction	Aster 9.02.18	Aster 9.02.21	
N1 NODE	1.2923446E+03	1.2923446E+03	-2.9E-06
N5 NODE	1.9925394E+03	1.9925394E+03	1.6E-06
N9 NODE	2.0643776E+03	2.0643776E+03	2.2 <sup>E</sup> -06

## 5 Summary of the results

The results are in concord with those obtained by CASTEM 2000, compared to the combination of modes CQC (error < 0.3%), for the cases mono-support and multi-support. The results got in mono-support on the one hand, and multi-support with excitations identical to the supports on the other hand, are equal and in conformity with those obtained by CASTEM 2000.