

## SDLS300 - Air cooler subjected to an excitation ground

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### Summary:

The scope of application of this test is the seismic analysis. The studied structure is an air cooler subjected to an excitation ground.

Displacements are calculated along meridian in the plan  $XZ$ .

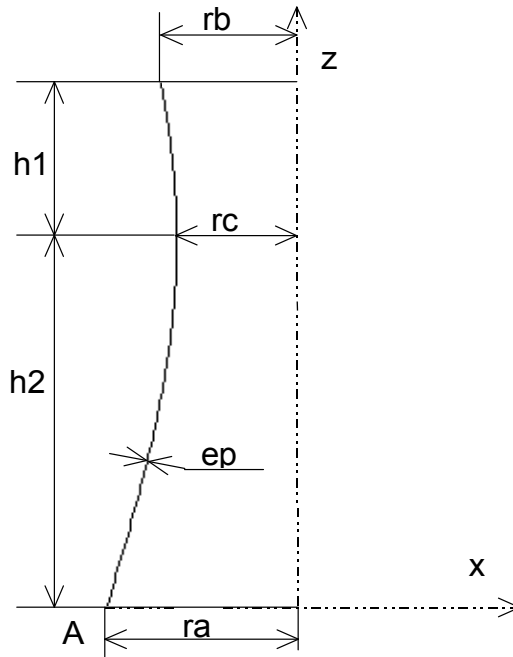
The objective is to test axial, tangential and normal displacements for the modal recombinations  $CQC$  and  $SRSS$ , for elements hull 3D.

Displacements of reference come from results got by several computer codes.

One is interested more particularly in calculation of the Eigen frequencies of this system. The values of reference are obtained on a model of Fourier with the computation software of structures the SAMCEF software.

## 1 Problem of reference

### 1.1 Geometry



The structure is defined by two arcs of hyperbole.

#### Dimensions:

$$\begin{aligned}ra &= 55.587 \text{ m} \\rb &= 37.515 \text{ m} \\rc &= 35.532 \text{ m} \\h1 &= 30.16 \text{ m} \\h2 &= 107.01 \text{ m} \\ep &= 0.305 \text{ m}\end{aligned}$$

### 1.2 Properties of materials

$$\begin{aligned}E &= 2.76E10 \text{ Pa} \\v &= 0.166 \\\rho &= 2244 \text{ Kg/m}^3\end{aligned}$$

### 1.3 Boundary conditions and loading

#### Boundary conditions

Embedding of the air cooler on the level of the ground.

#### Loading:

The air cooler is subjected to an excitation in the direction  $x$  on the level of embedding. Calculation is carried out starting from the spectrum of answer of speed [Figure 1.3-a].

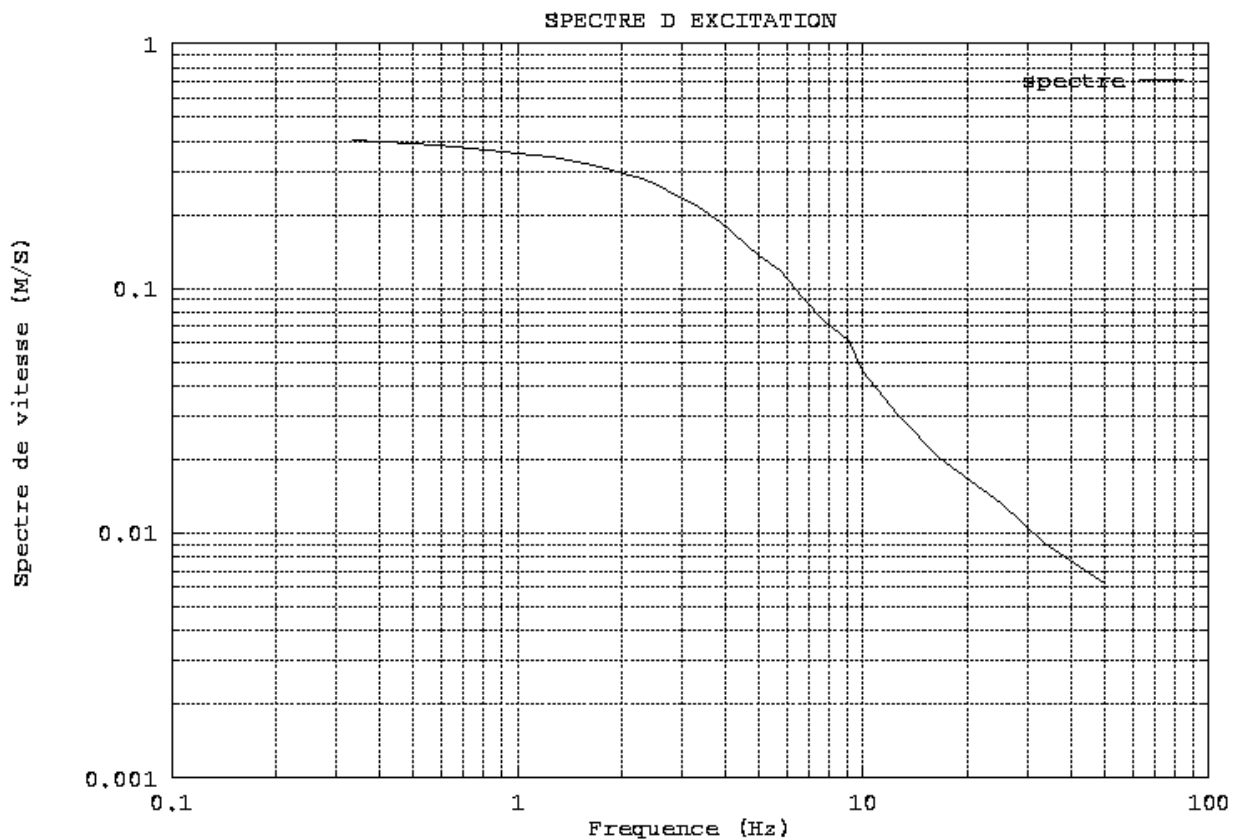


Figure 1.3-a: Spectrum of answer of speed

## 2 Reference solution

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

The spectral analysis is carried out with code CASTEM 2000.

### 2.2 Results of reference

- 1) Frequencies calculated with the SAMCEF software.
- 2) Axial, tangential displacements and normal along the wall located in the plan  $xOz$  ( $x$  and  $z$  positive) for the modal recombinations *CQC* and *SRSS*. (Calculated by taking of to account 4 modes).

In order to improve the identification of the modes, one evaluates the spectrum with a model of Fourier. This modeling was carried out with software the SAMCEF software. The spectrum being very dense, the following table presents only the frequencies lower than  $4 Hz$ .

Harmonic N°	Frequencies
4	1.14
5	1.17
3	1.24
4	1.35
6	1.45
5	1.50
2	1.53
6	1.62
7	1.70
3	1.73
5	1.93
8	1.96
7	2.03
6	2.09
9	2.26
7	2.28
6	2.42
8	2.45
4	2.47
7	2.55
10	2.60
8	2.67
1	2.80
9	2.82
11	2.98
5	3.01
8	3.04
8	3.10
7	3.10
2	3.20
10	3.21
9	3.29
9	3.37
12	3.40
6	3.56
11	3.65
9	3.70
10	3.80
3	3.81
8	3.83
13	3.86
9	3.91

## 2.3 Uncertainty on the solution

Comparisons between codes.

## 2.4 Bibliographical references

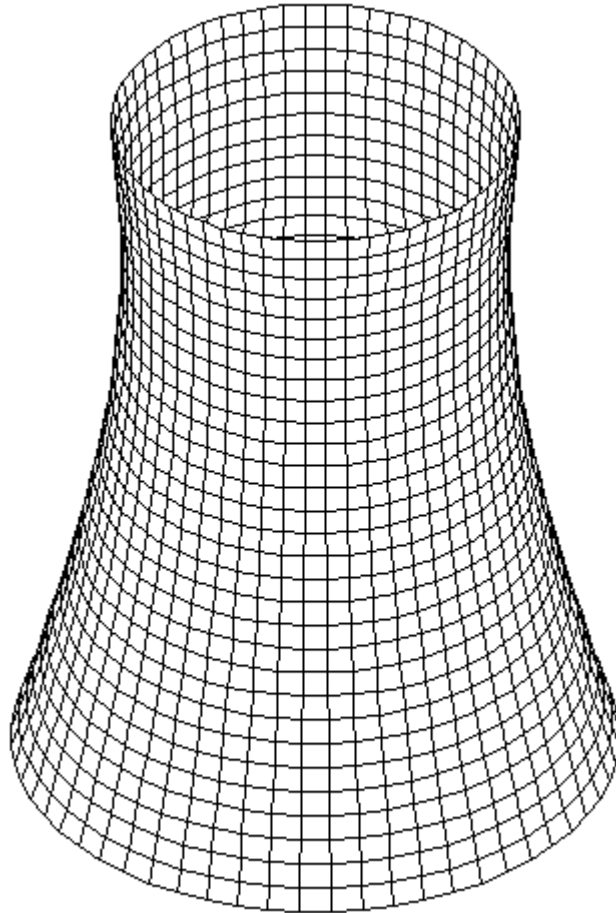
The case test is inspired by the following reference:

- 1) P.L. GOULD and S.H. ABU SITTA: Dynamic answer of structures to wind and earthquake loading PENTECH NEAR

## 3 Modeling A

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### 3.1 Characteristics of modeling



### 3.2 Characteristics of the grid

The grid consists of 1860 nodes and 1800 elements hull DKT.

## 3.3 Sizes tested and results

Eigen frequencies ( $Hz$ )

Only effective frequencies having a mass higher than 0.1% are indicated in the table below.

Number of the mode	Ref. (The SAMCEF software)	Code_Aster	Difference between the SAMCEF software and Code_Aster in %
1	2.80058	2.80065	0,003
2	2.80058	2.80065	0,003
3	5.92549	5.92490	-0,010
4	5.92549	5.92490	-0,010

These four modes make it possible to obtain a good representation of the mass in the direction of excitation since the effective mass according to X rises with 83.2%

Horizontal displacement  $x(m)$  :

Altitude (m)	CASTEM 2000		Code_Aster		Variation (%)	
	CQC	SRSS	CQC	SRSS	CQC	SRSS
13.3	1.318E-03	1.316E-03	1,538 E-03	1,432 E-03	16,653	8,740
26.8	1.484E-03	1.485E-03	2,853 E-03	2,669 E-03	92,155	79,744
40.3	1.898E-03	1.898E-03	4,456 E-03	4,249 E-03	134,714	123,819
49.4	2.4448E-03	2.442E-03	5,693 E-03	5,495 E-03	132,872	124,948
63.08	3.278E-03	3.275E-03	7,822 E-03	7,657 E-03	138,603	133,751
76.8	4.570E-03	4.568E-03	1,026 E-02	1,014 E-02	124,510	121,860
90.7	5.918E-03	5.918E-03	1,293 E-02	1,283 E-02	118,516	116,802
100	7.023E-03	7.024E-03	1,477 E-02	1,467 E-02	110,294	108,862
109.3	7.677E-03	7.677E-03	1,658 E-02	1,648 E-02	115,998	114,614
127.9	9.053E-03	9.054E-03	1,990 E-02	1,975 E-02	119,818	118,117

Vertical displacement  $z(m)$  :

Altitude (m)	CASTEM 2000		Code_Aster		Variation (%)	
	CQC	SRSS	CQC	SRSS	CQC	SRSS
13.3	4.534E-04	4.540E-04	8,297 E-04	8,101 E-04	82,955	78,407
26.8	6.832E-04	6.832E-04	1,712 E-03	1,674 E-03	150,528	145,025
40.3	1.091E-03	1.091E-03	2,464 E-03	2,408 E-03	125,872	120,680
49.4	1.510E-03	1.510E-03	2,892 E-03	2,823 E-03	91,521	86,877
63.08	1.794E-03	1.795E-03	3,424 E-03	3,337 E-03	90,769	85,848
76.8	1.944E-03	1.945E-03	3,840 E-03	3,737 E-03	97,437	92,035
90.7	2.024E-03	2.025E-03	4,173 E-03	4,056 E-03	106,143	100,213
100	2.114E-03	2.115E-03	4,372 E-03	4,244 E-03	106,767	100,630
109.3	2.187E-03	2.188E-03	4,564 E-03	4,427 E-03	108,645	102,266
127.9	2.356E-03	2.358E-03	4,959 E-03	4,803 E-03	110,427	103,663

## 3.4 Remarks

These four modes make it possible to obtain a good representation of the mass in the direction of excitation since the effective mass according to  $x$  rise with 83.2% .

Calculation is carried out without the taking into account of the neglected modes.

## 4 Summary of the results

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One is interested in two the first hundred modes of the structure: those are located in the band  $0 - 7 \text{ Hz}$  .  
One finds these frequencies well with *Code\_Aster* with a maximum change compared to the reference solution of 1.7% .

Four modes make it possible to obtain an effective mass cumulated according to  $x$  and  $y$  of 83.2% .  
Effective mass cumulated according to  $z$  is worthless. These effective weight breakdowns are identical to those obtained with the SAMCEF software.

For seismic calculation, displacements obtained are far away from the reference solution. However, one can express some doubts on the validity of these results of reference, being given the bad representation of the mass: indeed, for this calculation of reference, the effective mass cumulated in the direction  $x$  represent 43% total mass. This is why this part of calculation was put in comment in the CAS-test.