# SDLS300 - Air cooler subjected to an excitation ground

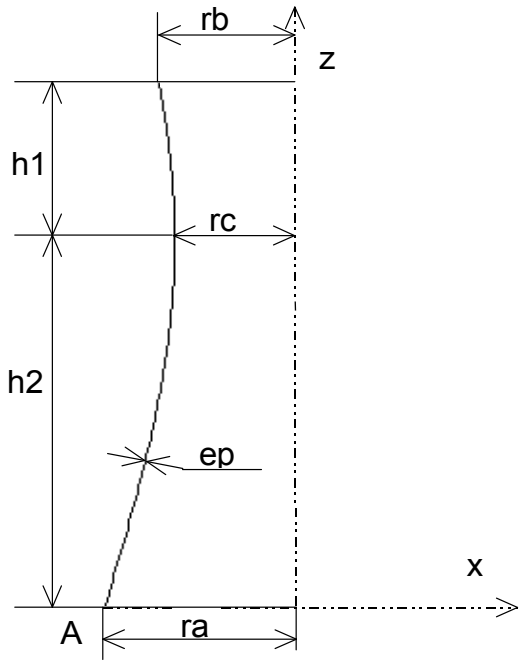
**Summary:**

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:**

$ra = 55.587\,m$
$rb = 37.515\,m$
$rc = 35.532\,m$
$h1 = 30.16\,m$
$h2 = 107.01\,m$
$ep = 0.305\,m$

## 1.2 Properties of materials

$E = 2.76\text{E}10\,Pa$
$\nu = 0.166$
$\rho = 2244\,Kg/m^3$

## 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].

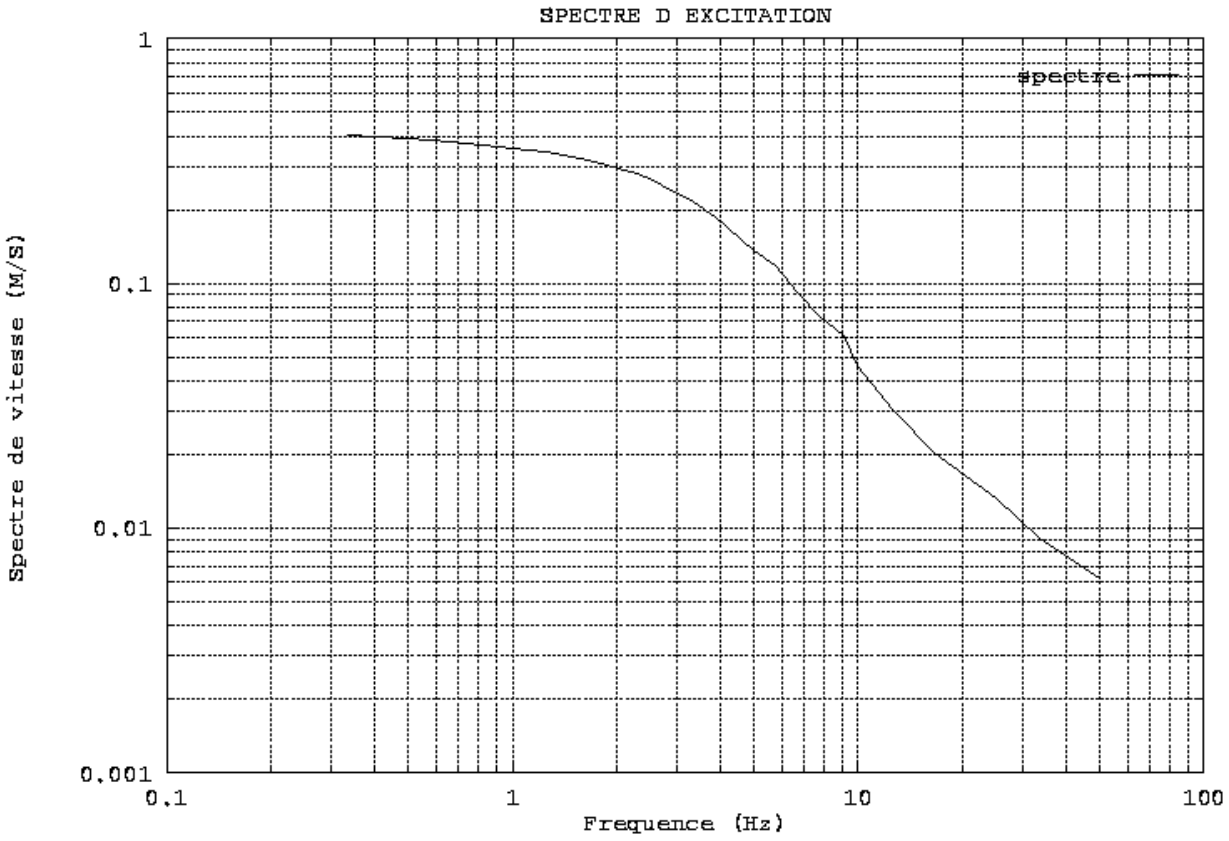



**Figure 1.3-a: Spectrum of answer of speed**

# 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.

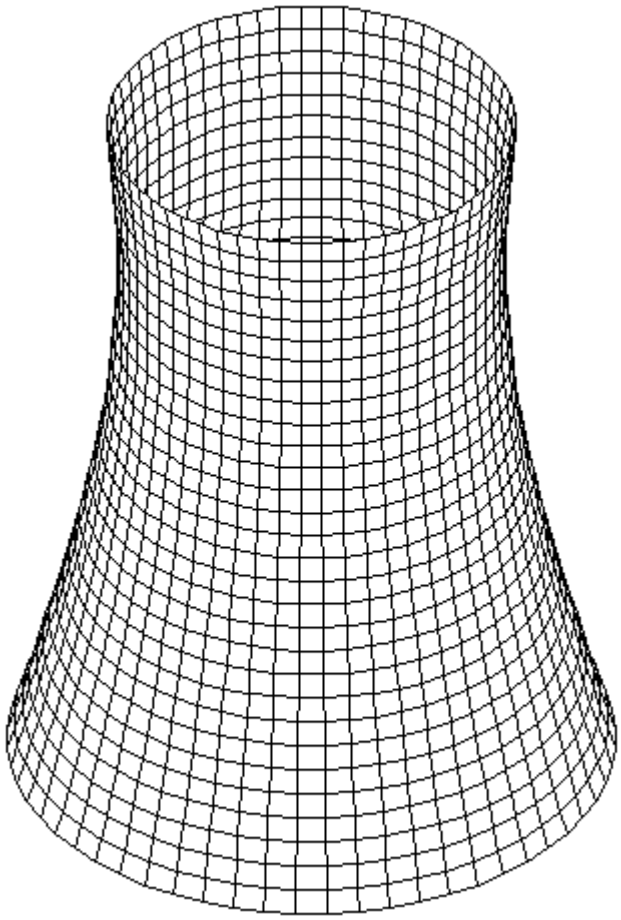
## 2.4 Bibliographical references

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

## 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 | CASTEM 2000 | | *Code_Aster* | | Variation (%) | |
|---|---|---|---|---|---|---|
| (m) | 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 | CASTEM 2000 | | *Code_Aster* | | Variation (%) | |
|---|---|---|---|---|---|---|
| (m) | 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

One is interested in two the first hundred modes of the structure: those are located in the band $0-7\,Hz$ .
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.