FDLV114 - Seismic answer of a cylindrical tank

Summary:

The objective of this test is to validate the seismic answer of a cylindrical tank.

In particular in modeling A one validates the taking into account of the impulsive contribution of the fluid contained in the tank by a method of added mass, the calculation of the factor of participation and effective modal masses of the wet modes.

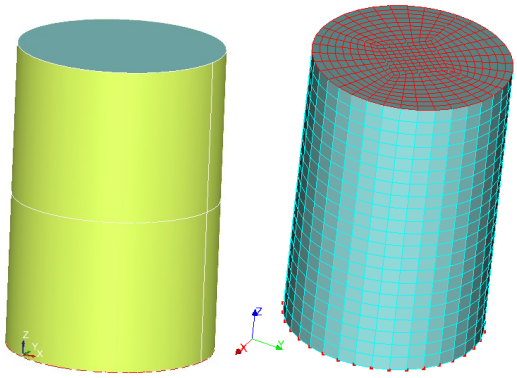
The fundamental frequency is compared with the result given by software NOVAX. In the same way one compares the answer of the tank filled with a spectrum with ground with the results given by NOVAX.

1 Problem of reference

1.1 Geometry, materials and boundary conditions

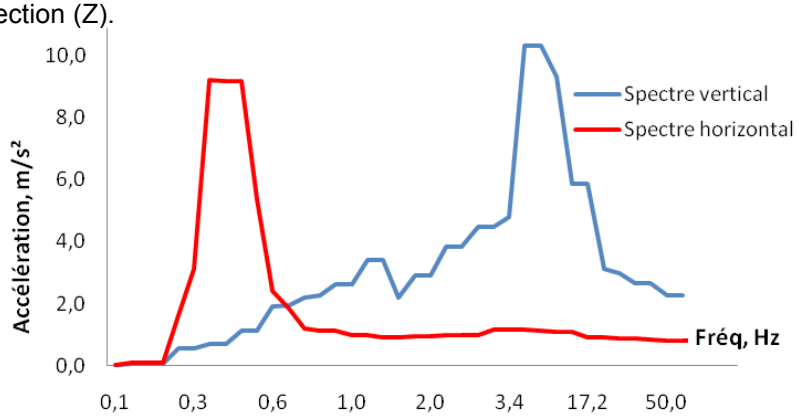
It is about a structure with simple geometry, of type rolls thin, filled to the brim and subjected to a definite seismic excitation with spectra of request.

- geometrical parameters of the cylinder:
  - ray R = 7 m,
  - height H = 21 m,
  - thickness of sheet E = 15 mm,
- parameters material:
  - Young modulus of the structure (steel) $E = 1.95 \cdot 10^{11}$ Pa,
  - Poisson's ratio v = 0.3,
  - density of the structure ρ = 7850 kg/m^3,
  - density of the liquid (water) ρ_L = 1000 kg/m^3,
  - damping C = 4%,
- boundary conditions:
  - base cylinder (lower surface) blocked according to three degrees of freedom (DDL) of translation,
  - worthless pressure on the level of the free surface of the fluid.



1.2 Seismic excitation

The sismisque loading is given by a spectrum of ground in the two horizontal directions (X and Y) and in the vertical direction (Z).



2 Reference solution

The reference solution is given by a software used by the ECA and AREVA: NOVAX. In the report [1], one will find the details of the results, as well as the comparison with software ANSYS and SYSTUS or the lawful approach recommended by Eurocode 8.

[1] CR-AMA-14.014 Benchmark EDF-AREVA on the modeling of the interaction fluid-structure in earthquake (project P11Q7 “GEN4: phase 3”)

3 Modeling A

3.1 Characteristics of modeling

A modeling is used DKT for the envelope of the tank and elements 3D for the fluid.

3.2 Sizes tested and results

One tests the frequency of the first wet mode.

Identification	Type of reference	Value of reference	Tolerance
Mode 1	'SOURCE_EXTERNE'	4.29 Hz	3%

One tests also the response in displacement to the top of the tank to the earthquake in the horizontal direction.

Identification	Type of reference	Value of reference	Tolerance
Summit of the cylinder DX	'SOURCE_EXTERNE'	2.47 mm	14%

4 Modeling B

4.1 Characteristics of modeling

In modeling B, one does the same calculation as in modeling A, however by breaking up it into a first part where one explicitly obtains the fluid potential associated with the modes with structure of the tank.

4.2 Sizes tested and results

The added mass of the first mode is calculated by projection of the fluid potential of displacement on itself. The result is compared with that given by the operator CALC_MATR_AJOU.

Identification	Type of reference	Value of reference	Tolerance
Mass added of the first mode on itself	'AUTRE_ASTER'	96633 kg	0.1 %

One deduces then the potentials in pressure and of speed by a factor ω or ω^2, ω being the frequency of the mode in question.

5 Summary of the results

This your valid calculation and the taking into account of the factors of participation calculated on a generalized modal basis. They are calculated in the typical case of modes with mass added and used to determine the seismic answer of a cylindrical tank filled with water.

The results are relatively far away from the reference (variation of 15 % compared to other software). These differences are due to the fact that to approach some it is necessary to use a modal base in air wide (up to 300 Hz). Calculation is feasible (lower than one hour of calculation) but does not return then any more within the framework of the elementary checking.