SDLX300 - Piping subjected to an excitation in displacement, speed, acceleration

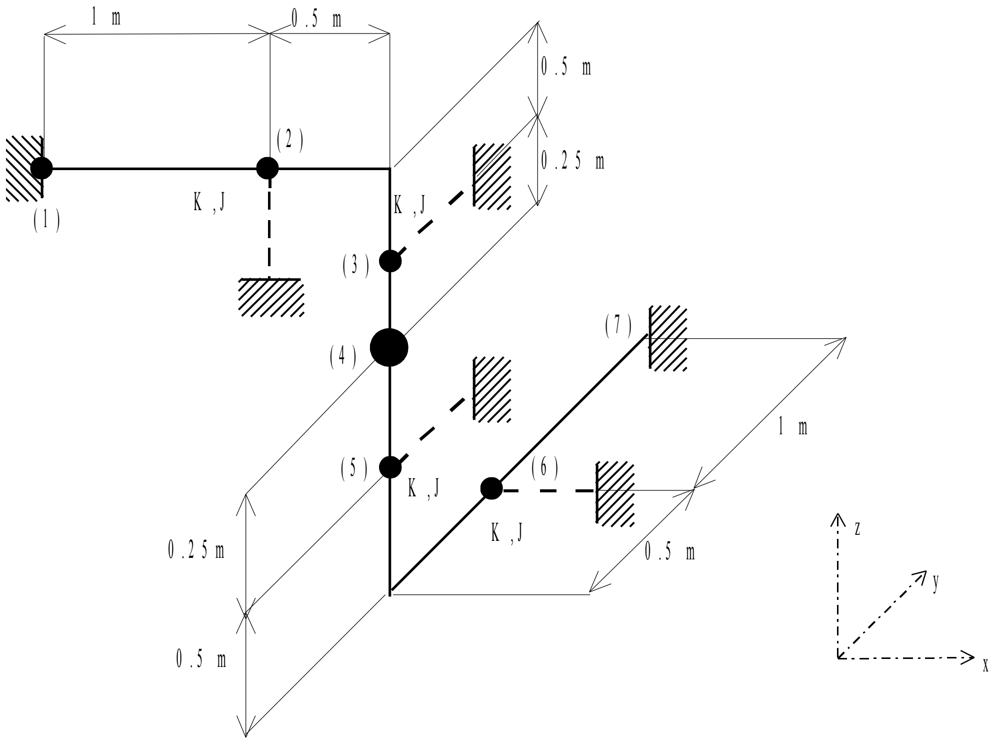
Summary:

Three-dimensional study of a piping embedded-rotulée with localised stiffnesses and mass subjected to an excitation in displacement, speed and acceleration.

The reference is obtained for 6 modes with CASTEM 2000.

1 Problem of reference

1.1 Geometry



External diameter	:	$48.E-3\,m$
Thickness	:	$5.E-3\,m$
Radius of curvature of the elbows	:	$0.170\,m$

1.2 Properties of materials

Density	:	$7960.\,kg.m^{-3}$
Young modulus	:	$1.9\,E+11\,N.m^{-2}$
Poisson's ratio	:	0.3
Mass concentrated with Nœud 4	:	$10.\,kg$

1.3 Boundary conditions and loadings

1.3.1 Boundary conditions

With Nœud 1: $dx=dy=dz=0$ (kneecap)
With Nœud 7: $dx=dy=dz=drx=dry=drz=0$ (embedding)

With Nœud 2, self-supporting quality in the direction z
With Nœud 3, self-supporting quality in the direction y
With Nœud 5, self-supporting quality in the direction y
With Nœud 6, self-supporting quality in the direction x

The stiffnesses brought by each self-supporting quality are:

$$K_x=K_y=K_z=80.E+3\,N.m^{-1} \qquad K_{\theta x}=K_{\theta y}=K_{\theta z}=J=1.2\,N.m.deg^{-1}$$

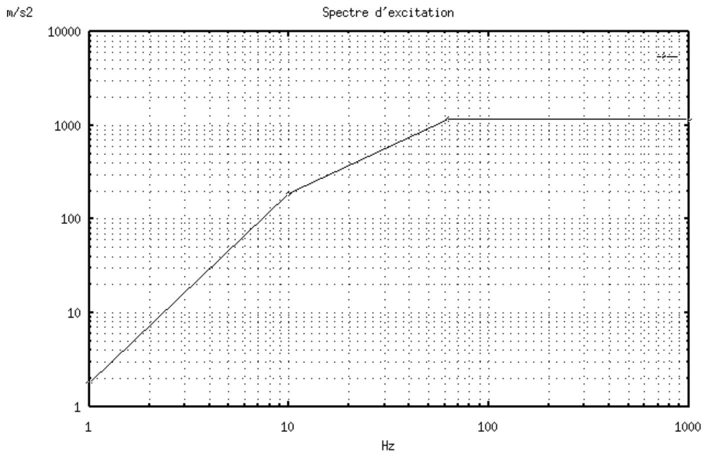
1.3.2 Loadings

Calculation of the static modes
The first calculation makes it possible to validate the calculation of the static modes.
The whole of the model is subjected to a constant acceleration according to x of value $100 \times g$ with $g = 9.81\, m.s^{-2}$

Spectral response
One subjects the line of piping to an excitation according to x, defined by a spectrum of answer such as:

- its value in displacement for frequencies ranging between 1. and 10. Hz, that is to say $d = 48.\mathrm{E}-3\mathrm{m}$
- its value of speed for frequencies ranging between 10. and 63. Hz, that is to say $v = 3.\mathrm{m.s}^{-1}$
- its value in acceleration for frequencies ranging between 63. and 1000. Hz, that is to say $\gamma = 120 * g$

Below the spectrum of acceleration, determined starting from the excitation for a reduced damping is represented $\xi = 0$.



The characteristic values used are:

$\gamma(1\, Hz) = 1.92 \mathrm{m}/s^2 \quad \gamma(10\, Hz) = 192\, m/s^2 \quad \gamma(63\, Hz) = 1000\, m/s^2$
$\gamma(1000\, Hz) = 1000\, m/s^2$

1.3.3 Flexibility of the elbows

The coefficient of flexibility, C_{flex}, elbows is given by regulation RCC-M:

$$C_{flex} = \frac{1.65}{h} \text{ with } h = \frac{ep * r_{courb}}{r_m^2}$$

ep : thickness of the elbow
r_{courb} : radius of curvature of the elbow
r_m : average radius of the elbow

The index of intensification of the constraints, I_{sigm}, is given by:

$$I_{sigm} = \frac{0.9}{h^{0.666}}$$

According to regulation RCC-M, the coefficient of flexibility and the index of intensification of the constraints are equal to or higher than one. It is not the case in this CAS-test.

2 Reference solution

2.1 Method of calculating used for the reference solution

The reference is obtained for 6 modes with Castem 2000, for the method of modal recombination CQC.

2.2 Results of reference

Modal calculation
Effective frequencies, masses according to x, y, z

Static mode
Displacements with the characteristic nodes

Spectral response
Displacements and efforts generalized with Nœuds characteristic
Reaction to embedding

The results are got with 6 modes for the modal recombination CQC.

2.3 Uncertainty on the solution

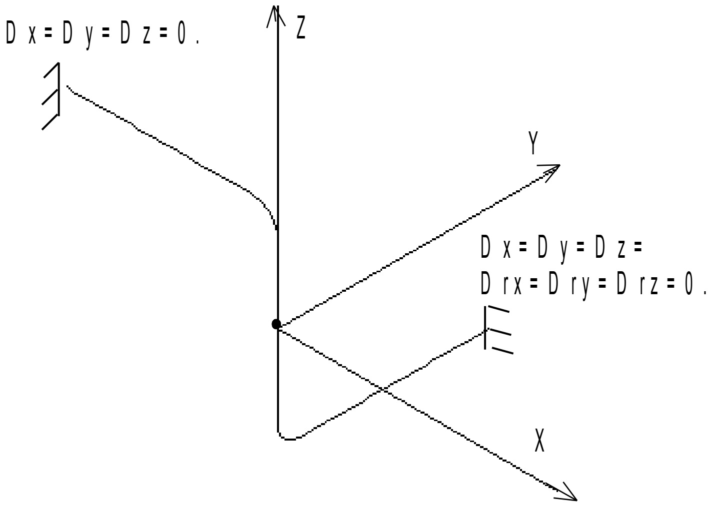
Comparison between codes

2.4 Bibliographical references

[1] B. Kurth - P. Pasquet: Calculation of a piping - Test Castem2000 DCN - Cherbourg. Reference CISI 93020

3 Modeling A

3.1 Characteristics of modeling



3.2 Characteristics of the grid

The grid consists of 88 elements right beam of Timoshenko.

4 Sizes tested and results of modeling A

At the time of the passage of the modeling of the elbows in POU_D_T, certain tests were removed because the results were too far away from the reference. The sign * means that the test was removed.

4.1 Calculation of the modal base

Eigen frequencies of the structure (Hz)

Number of mode	Reference
1	1.6848E+01
2	2.0762E+01
3	2.2386E+01
4	4.4822E+01
5	5.2218E+01
6	7.9692E+01

Effective masses according to the direction x (kg)

Number of mode	Reference
1	1.6134E+00
2	4.4041E-01
3	1.8187E+01
4	1.0628E-02
*5	3.8555E-02
*6	7.7799E-02

Effective masses according to the direction y (kg)

Number of mode	Reference
1	9.2479E+00
2	1.1224E+01
3	1.7076E-01
4	6.7896E-01
*5	1.1784E-03
*6	4.2460E-02

Effective masses according to the direction z (kg)

Number of mode	Reference
1	1.3324E+01
*2	1.1625E+01
3	2.8852E+00
4	4.1979E-01
5	2.5868E-01
*6	6.5858E-01

4.2 Loading a: Calculation of the static modes

Displacements (m)

Direction	Nodes	Reference
Ux	2	1.001E-04
	*3	3.169E-02
	4	4.830E-02
	5	6.162E-02

	6	4.527E-02
Uy	2	3.823E-03
	3	7.525E-03
	4	5.556E-03
	5	3.777E-03
	6	– 4.516E-06
Uz	*2	– 6.607E-03
	*3	1.032E-02
	*4	1.031E-02
	*5	1.031E-02
	6	5.632E-03

4.3 Loading b: Spectral response

Calculation with 6 modes - quadratic modal recombination supplements 'CQC'
Displacements (m)

Direction	Nodes	Reference
Ux	2	1.859E-05
	3	1.092E-02
	4	1.722E-02
	5	2.259E-02
	*6	1.695E-02
Uy	2	6.765E-03
	3	6.555E-03
	4	5.029E-03
	5	3.398E-03
	*6	2.398E-06
Uz	*2	1.004E-02
	3	7.574E-03
	4	7.575E-03
	5	7.574E-03
	6	4.238E-03

Reaction (N) and Moment ($N.m$) with Nœud 7

	Reference
Fx	1.284E+03
* Fy	3.079E+02
Fz	4.070E+02
Mx	3.748E+02
* My	2.301E+02
Mz	1.431E+03

Generalized efforts
Table n°1 (*)

Nodes	Components	Reference
2	* $Fx(N)$	2.385E+03
	$Fy(N)$	2.275E+02
	* $Fz(N)$	5.183E+02
	$Mx(N.m)$	3.067E-01
	$My(N.m)$	7.984E+02
	$Mz(N.m)$	2.367E+02
3	$Fx(N)$	6.092E+02
	$Fy(N)$	2.555E+02

	$Fz(N)$	2.151E+03
	$Mx(N.m)$	3.611E+02
	$My(N.m)$	1.417E+02
	$Mz(N.m)$	1.114E+02
4	$Fx(N)$	8.733E+02
	$Fy(N)$	3.777E+02
	$Fz(N)$	2.665E+03
	$Mx(N.m)$	3.617E+02
	$My(N.m)$	6.081E+02
	$Mz(N.m)$	1.894E+02
5	$Fx(N)$	6.373E+02
	$Fy(N)$	4.489E+02
	$Fz(N)$	1.284E+03
	$Mx(N.m)$	3.615E+02
	$My(N.m)$	3.416E+02
	$Mz(N.m)$	1.766E+02
6	* $Fx(N)$	3.078E+02
	$Fy(N)$	1.922E+03
	$Fz(N)$	5.692E+02
	$Mx(N.m)$	2.306E+02
	$My(N.m)$	1.420E+02
*	$Mz(N.m)$	3.415+02

See remark [§ 4.4].

Table n°2 (*)

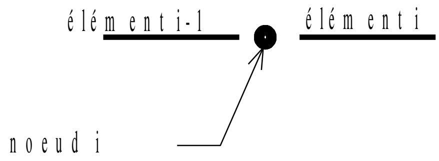
Nodes	Components	Reference
2	$Fx(N)$	2.387E+03
	$Fy(N)$	4.333E+02
	$Fz(N)$	1.164E+03
	$Mx(N.m)$	2.781E-01
	$My(N.m)$	7.985E+02
	$Mz(N.m)$	2.368E+02
3	$Fx(N)$	9.656E+02
	$Fy(N)$	4.511E+02
	$Fz(N)$	2.955E+03
	$Mx(N.m)$	3.618E+02
	$My(N.m)$	1.429E+02
	$Mz(N.m)$	1.113E+02
4	$Fx(N)$	5.281E+02
	* $Fy(N)$	3.928E+02
	* $Fz(N)$	8.652E+02
	$Mx(N.m)$	3.616E+02
	$My(N.m)$	6.081E+02
	$Mz(N.m)$	1.894E+02
5	$Fx(N)$	2.223E+02
	* $Fy(N)$	2.753E+02
	$Fz(N)$	4.752E+02

	$Mx(N.m)$	3.627E+02
	$My(N.m)$	3.403E+02
	$Mz(N.m)$	1.766E+02
6	* $Fx(N)$	3.076E+02
	$Fy(N)$	6.588E+02
	$Fz(N)$	2.842E+02
	$Mx(N.m)$	2.299E+02
	$My(N.m)$	1.418E+02
	* $Mz(N.m)$	3.396E+02

* See remark [§ 4.4].

4.4 Remarks

For a node i given, effort generalized for the element $i-1$ and for the element i is compared respectively in tables 1 and 2.



5 Summary of the results

Modal characteristics
The variations on the calculated frequencies remain lower than 0.4%.
The maximum change on the significant effective masses is of 4.4% (direction z). A variation of 24% is raised in the direction y , on the effective mass of the mode 6 which accounts for 0.15% of the total mass.

Static modes
The variations are about 1% in the directions y and z , and lower than 0.5% in the direction x .

Spectral response

Displacements
The variations are about 1%, with a variation of 4.6% for Nœud 6 in the direction y (but displacement with Nœud 6 is about 1.e-6 and is not significant compared to the other computed values, about 1.e-3).

Reactions to generalized embedding and efforts
The average deviation is about 2%. A variation of 12.8%, appears on the level of Nœud 5 for the component Fz generalized effort. There exists an order of magnitude between the value of the effort on the left and on the right of the mass, the variation on the minimal value of the effort is of 12.8%, 2.6% on the maximum value, and of 5% on the median value.