SDLL11 - Free-free thin circular ring

Summary:

This CAS-test makes it possible to test the frequencies and the modes of vibration of a circular ring into free-free.

Eight modelings are carried out, for each one among it one specifies the modeling and the type of mesh tested.

Method of research of the Eigen frequencies used is the method of SORENSEN for modelings A, B, C, D, E, F, G , and method of LANCZOS for modeling I .

- Modelings 3D
  - Modeling A : mesh HEXA20
  - Modeling B : mesh HEXA8
  - Modeling C : mesh PENTA15
  - Modeling D : mesh TETRA10
- Modeling POU_D_T
  - Modeling E : mesh SEG2
- Modelings 2D
  - Modeling F : mesh QUAD8
  - Modeling G : mesh QUAD8
  - Modeling I : mesh QUAD8

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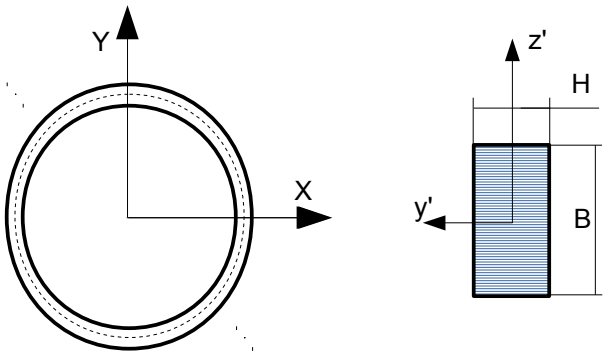
1 Problem of reference

1.1 Geometry



Dimension in (m)

- Average radius of curvature $R=0.1\mathrm{m}$
- Thickness: $h=0.005\,m$
- Width: $b=0.010\,m$ (perpendicular plan)
- Surface: $A=5\times10^{-5}\,m^2$
- Moment of inertia: $I_z=1.042\times10^{-10}\,m^4$ $I_y=4.167\times10^{-10}\,m^4$
- Torque: $J=2.859\times10^{-10}\,m^4$

1.2 Properties of material

- Rubber band
  - $E=7.2\times10^{10}\,Pa$ Young modulus
  - $\nu=0.3$ Poisson's ratio
  - $\rho=2700\,kg/m^3$ Density

1.3 Boundary conditions and loadings

- Displacements: all the points of the ring are free
- Loading: none

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2 Reference solution

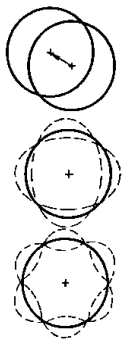
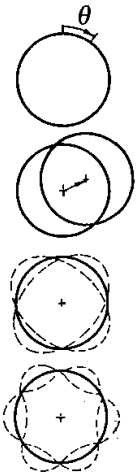
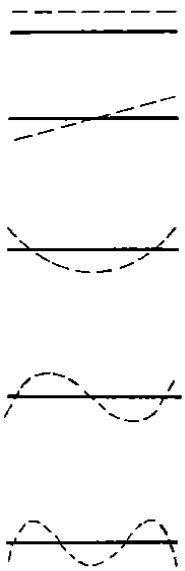
2.1 Method of calculating used for the reference solution

- Modes of vibration in the plan
  For these modes of vibration, the equation of inflection of the curved beams of V. Boussinesq (1883), without extension of neutral fibre leads to:

$$f_i=\frac{1}{2\pi}\sqrt{(\frac{i^2(i^2-1)^2}{i^2+1}\times\frac{EI_Z}{\rho AR^4})} \qquad i=0,1,2,...$$

  The reference solution is established for thin arcs such as $\alpha R\geq 100\sqrt{(\frac{I_z}{A})}$ with α, angle in the center in radians.

- Modes of vibration except plan
  For the transverse modes of vibrations with rectangular section, the solution was established starting from the results of two computer codes, using different formulations.

Clean modes in the plan (polar coordinates (i,θ))			Clean modes except plan
Symmetrical $u_i'=i\cos(i\theta)$ $v_i'=\sin(i\theta)$ $\theta_i'=-\frac{1-i^2}{R}\sin(i\theta)$		Antisymmetric $u_i'=i\sin(i\theta)$ $v_i'=-\cos(i\theta)$ $\theta_i'=-\frac{1-i^2}{R}\cos(i\theta)$	
	$i=0$ Overall rotation $i=1$ overall translation $i=2$ $i=3$		$i=0$ $i=1$ $i=2$ $i=3$ $i=4$ 

2.2 Reference variable

- $FREQ$: frequency

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2.3 Size and result of reference

	Component	Nature of the clean mode		Reference
		i	order	(Hz)
Modes in the plan	$FREQ$	2	4,5	318.36
		3	6,7	900.46
		4	8,9	1726.55
		5	10,11	2792.21
Transverse modes	$FREQ$	2	4,5	511.
		3	6,7	1590.
		4	8,9	3184.

2.4 Bibliographical references

[1] Guide of Validation of the Software packages of Calculations of the Structures: SFM, technical AFNOR, ISBN: 2-12-486611-7

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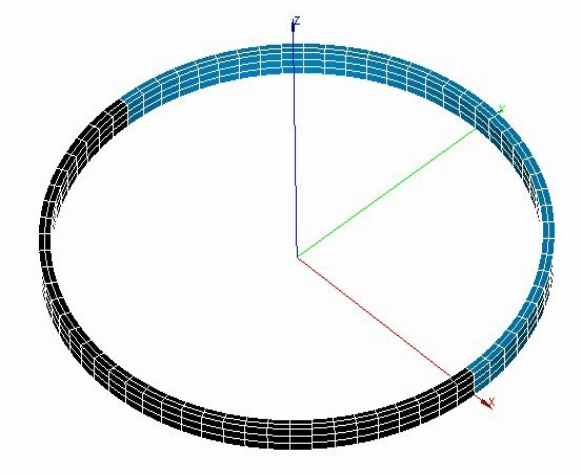
3 Modeling A

3.1 Characteristics of modeling A

- Modeling 3D



Many nodes	2952	
Many meshs	432	HEXA20

3.2 Sizes tested and results

	Component	Nature of the clean mode		Reference (Hz)	Tolerance $(\%)$
		i	order		
Modes in the plan	$FREQ$	2	4,5	318.36	0.1
		3	6,7	900.46	0.3
		4	8,9	1726.55	0.5
		5	10,11	2792.21	0.8
Transverse modes	$FREQ$	2	4,5	511.	0.7
		3	6,7	1590.	1.4
		4	8,9	3184.	2.3

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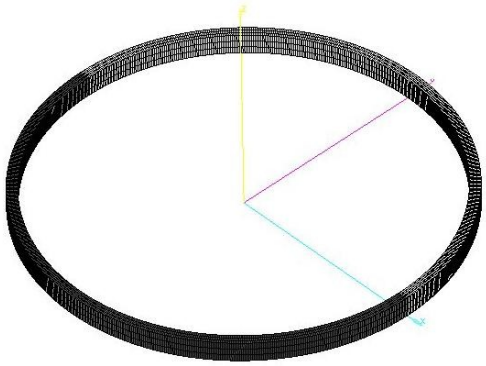
4 Modeling B

4.1 Characteristics of modeling B



Modeling 3D:

Many nodes	12800	
Many meshs	7200	HEXA8

4.2 Sizes tested and results

	Component	Nature of the clean mode		Reference (Hz)	Tolerance $(\%)$
		i	order		
Modes in the plan	$FREQ$	2	4,5	318.36	1.8
		3	6,7	900.46	1.6
		4	8,9	1726.55	1.35
		5	10,11	2792.21	1.
Transverse modes	$FREQ$	2	4,5	511.	1.7
		3	6,7	1590.	0.4
		4	8,9	3184.	0.8

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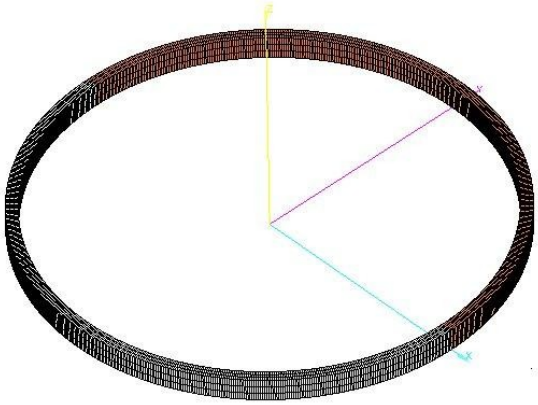
5 Modeling C

5.1 Characteristics of modeling C



Modeling 3D:

Many nodes	3528	
Many meshs	864	PENTA15

5.2 Sizes tested and results

	Component	Nature of the clean mode		Reference (Hz)	Tolerance $(\%)$
		i	order		
Modes in the plan	$FREQ$	2	4,5	318.36	0.1
		3	6,7	900.46	0.2
		4	8,9	1726.55	0.35
		5	10,11	2792.21	0.6
Transverse modes	$FREQ$	2	4,5	511.	0.7
		3	6,7	1590.	1.4
		4	8,9	3184.	2.3

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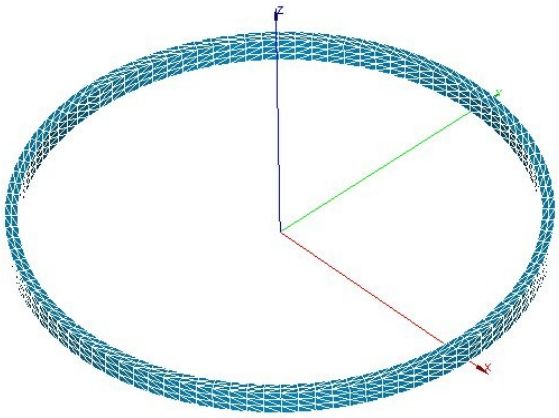
6 Modeling D

6.1 Characteristics of modeling D



Modeling 3D:

Many nodes	5824	
Many meshs	2728	TETRA10

6.2 Sizes tested and results

	Component	Nature of the clean mode		Reference (Hz)	Tolerance (%)
		I	order		
Modes in the plan	$FREQ$	2	4,5	318.36	0.1
		3	6,7	900.46	0.2
		4	8,9	1726.55	0.4
		5	10,11	2792.21	0.7
Transverse modes	$FREQ$	2	4,5	511.	0.25
		3	6,7	1590.	1.1
		4	8,9	3184.	2.0

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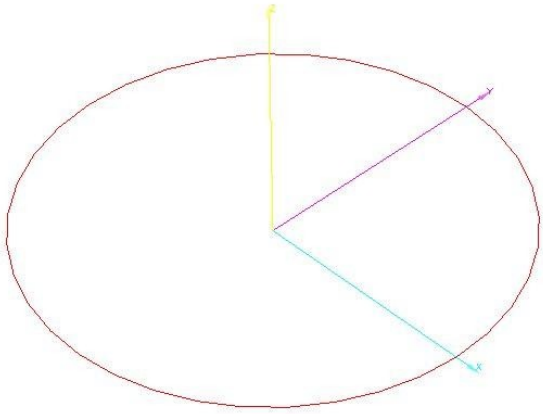
7 Modeling E

7.1 Characteristics of modeling



Modeling POU_D_T:

Many nodes	72	
Many meshs	72	SEG2

7.2 Sizes tested and results

	Component	Nature of the clean mode		Reference (Hz)	Tolerance $(\%)$
		i	order		
Modes in the plan	$FREQ$	2	4,5	318.36	0.25
		3	6,7	900.46	0.6
		4	8,9	1726.55	1.1
		5	10,11	2792.21	1.7
Transverse modes	$FREQ$	2	4,5	511.	0.85
		3	6,7	1590.	1.5
		4	8,9	3184.	2.4

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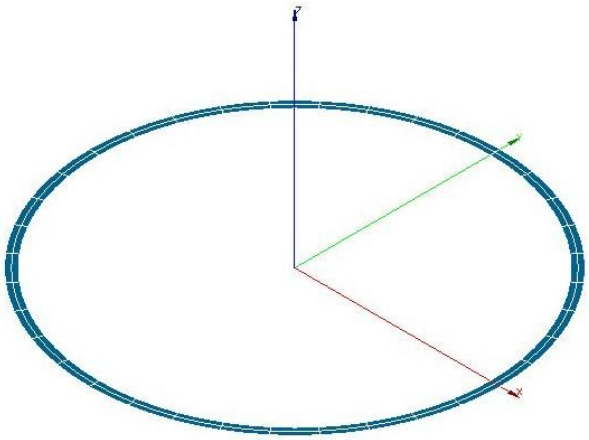
8 Modeling F

8.1 Characteristics of modeling F



Modeling D_PLAN:

Many nodes	288	
Many meshs	72	QUAD8

8.2 Sizes tested and results

	Component	Nature of the clean mode		Reference (Hz)	Tolerance $(\%)$
		i	order		
Modes in the plan	$FREQ$	2	4,5	318.36	1.4
		3	6,7	900.46	1.6
		4	8,9	1726.55	1.7
		5	10,11	2792.21	2.0

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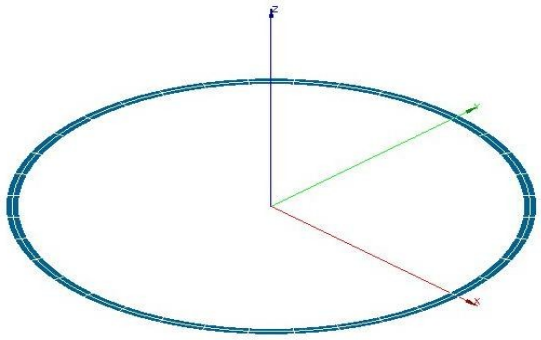
9 Modeling G

9.1 Characteristics of modeling G



Modeling C_PLAN:

Many nodes	293	
Many meshs	72	QUAD8

9.2 Sizes tested and results

	Component	Nature of the clean mode		Reference (Hz)	Tolerance $(\%)$
		i	order		
Modes in the plan	$FREQ$	2	4,5	318.36	1.4
		3	6,7	900.46	1.6
		4	8,9	1726.55	1.7
		5	10,11	2792.21	2.0

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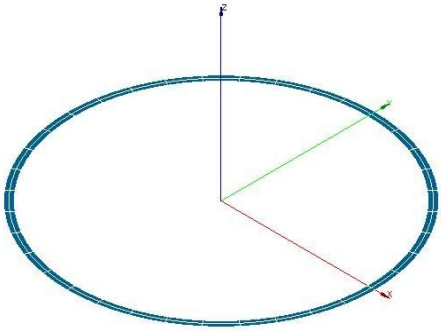
10 Modeling I

10.1 Characteristics of modeling I



Modeling C_PLAN:

Many nodes	293	
Many meshs	72	QUAD8

10.2 Sizes tested and results

	Component	Nature of the clean mode		Reference (Hz)	Tolerance $(\%)$
		i	order		
Modes in the plan	$FREQ$	2	4,5	318.36	1.4
		3	6,7	900.46	1.6
		4	8,9	1726.55	1.7
		5	10,11	2792.21	2.0

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11 Summary of the results

The got results are satisfactory.

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