SDLS04 - Cyclic substructuring: Annular thin plate embedded in its Summarized

hub:

The scope of application of this test relates to the dynamics of structures, and more particularly modal computation by cyclic dynamic substructuring.

It is a question of calculating the eigen modes of an axisymmetric structure (annular thin plate embedded in its hub) by regarding it as a structure with cyclic repetitivity.

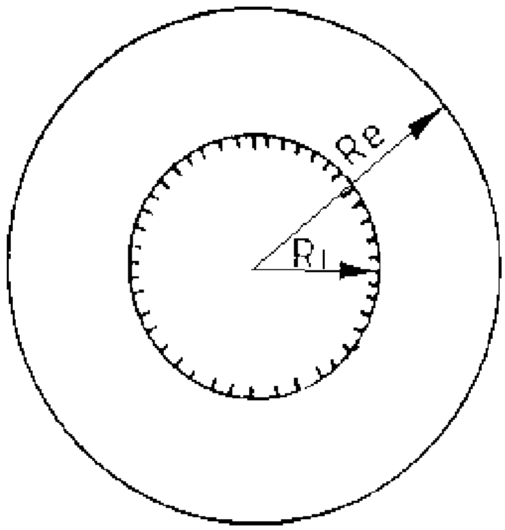
The model consists of an angular sector of $20°$ ring, with a grid in triangles to which are affected elements of plate type: DKT. Two methods of calculating are tested:

- Cyclic dynamic substructuring of cyclic
- Craig-Bampton dynamic Substructuring of Mac Neal

the results of reference result from an analytical computation. They validate the tools for modal computation by under - cyclic dynamic structuring implemented in *Code_Aster*.

1 Problem of reference

1.1 Geometry



interior Radius: $R_i = 0.1\,m$
External radius: $R_e = 0.2\,m$
Thickness: $t = 0.001\,m$

1.2 Material properties

$E = 2.10^{11}\,Pa$

$\nu = 0.3$

$\rho = 7\,800\,\mathrm{kg}/m^3$

1.3 Boundary conditions and loadings

Fixed support with the hub

For any point $r = R_i$, $u = v = w = 0.$ and $\theta_x = \theta_y = \theta_z = 0$.

1.4 Initial conditions

Without object for the modal analysis.

2 Reference solution

2.1 Method of calculating used for the reference solution

the reference solution is that given in file SDLS04/89 of the guide VPCS which presents the analytical solution in the following way:

The solution of the determinant of the frequencies established starting from the functions of Bessel leads to the formula:

$$f_{ij}=\frac{1}{2\pi R_e^2}\lambda_{ij}^2\sqrt{\frac{E t^2}{12\rho(1-\nu^2)}}$$

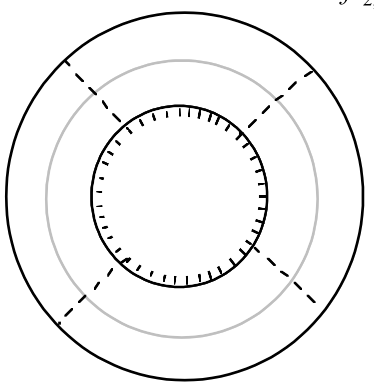
With:

- i = many nodal diameters
- j = many nodal circles

and λ_{ij}^2 such as:

I / J	0	1	2	3
0	13.0	13.3	14.7	18.5
1	85.1	86.7	91.7	100.

Mode of bending to 2 nodal diameters and 1 nodal circle: $f_{2,1}=559{,}09\ Hz$



2.2 Results of reference

8 eigen modes.

2.3 Uncertainty on the analytical

solution Solution.

2.4 Bibliographical references

1) A.W. LEISSA, Vibration of punts, Document NASA SP160, 1969, p. 19-30.

3 Modelization A

3.1 Characteristic of the modelization

This structure with cyclic repetitivity is studied using the method of cyclic dynamic substructuring of CRAIG-BAMPTON.

A basic sector, consisted an angular sector of $20°$, is with a grid in triangles to which shell elements DKT are affected.

The modal base used for the sector is made up of 20 eigen modes and **the constrained modes** associated with the interfaces.

3.2 Characteristics of the mesh

Many nodes: 66.

Number of meshes and types: 100 triangles with 3 nodes DKT

3.3 Quantities tested and Number

Sequence number	results of nodal diameters i	Number of nodal circles j	Reference	*Aster*	% difference
1	0	0	79.26	79.58	0.4
8	0	1	518.85	519.54	0.1.2.3
	1	0	81.09	81.18	0.1
9.10	1	1	528.61	529.50	0.2.4.5
	2	0	89.63	89.72	0.1
11.12	2	1	559.09	559.48	0.07
6.7	3	0	112.79	113.16	0.3
13.14	3	1	609.70	609.75	0.01

3.4 Remarks

the modes with more than 1 modal diameter are double modes.

4 Modelization B

4.1 Characteristic of the modelization

This structure with cyclic repetitivity is studied using the method of cyclic dynamic substructuring of MAC-NEAL.

A basic sector, consisted an angular sector of $20°$, is with a grid in triangles to which shell elements DKT are `affected`.

The modal base used for the sector is made up of 20 eigen modes and **the attach modes** associated with the interfaces.

4.2 Characteristics of the mesh

Many nodes: 66.

Number of meshes and types: 100 triangles with 3 nodes `DKT`

4.3 Quantities tested and Number

nodal	results of Sequence number diameter i	Number of nodal circles j	Reference	*Aster*	% difference
1	0	0	79.26	79.58	0.4
8	0	1	518.85	519.53	0.1.2.3
	1	0	81.09	81.18	0.1
9.10	1	1	528.61	529.50	0.2.4.5
	2	0	89.63	89.72	0.1
11.12	2	1	559.09	559.48	0.07
6.7	3	0	112.79	113.16	0.3
13.14	3	1	609.70	609.76	0.01

4.4 Remarks

the modes with more than 1 modal diameter are double modes.

5 Summary of the results

frequencies calculated by cyclic substructuring, that it is by the method of Craig-Bampton or the method of Mac Neal, different from direct modal computation from less 1% .
This test validates the two methods of substructuring.