

SDLS04 - cyclic Under-structuring: Annular thin section embedded in its hub

Summary:

The scope of application of this test relates to the dynamics of the structures, and more particularly modal calculation by cyclic dynamic under-structuring.

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

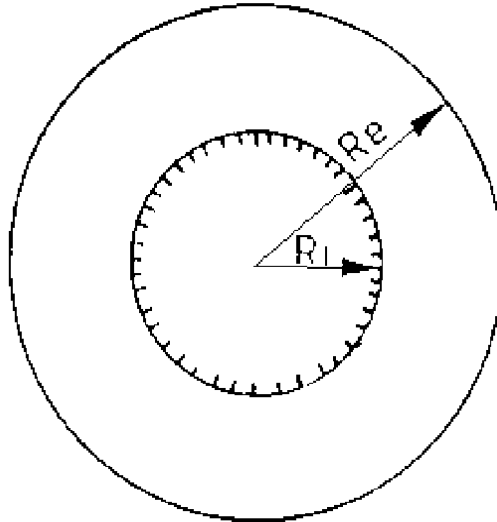
The model consists of an angular sector of 20° ring, with a grid in triangles to which are affected of the elements of the type plates: DKT. Two methods of calculating are tested:

- cyclic dynamic Under-structuring of Craig-Bampton
- cyclic dynamic Under-structuring of Mac Neal

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

1 Problem of reference

1.1 Geometry



Interior ray: $R_i = 0.1 \text{ m}$
External ray: $R_e = 0.2 \text{ m}$
Thickness: $t = 0.001 \text{ m}$

1.2 Material properties

$E = 2.10^{11} \text{ Pa}$
 $\nu = 0.3$
 $\rho = 7800 \text{ kg/m}^3$

1.3 Boundary conditions and loadings

Embedding 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 card 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:

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

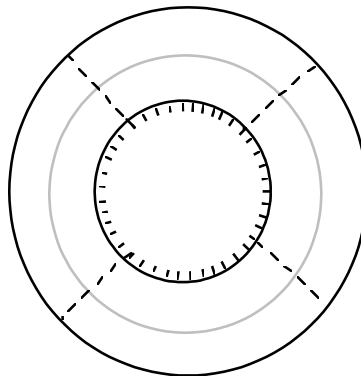
With:

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

and λ_{ij}^2 such as:

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

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



2.2 Results of reference

8 clean modes.

2.3 Uncertainty on the solution

Analytical solution.

2.4 Bibliographical references

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

3 Modeling A

3.1 Characteristics of modeling

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

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

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

3.2 Characteristics of the grid

Many nodes: 66.

Many meshes and types: 100 triangles with 3 nodes DKT

3.3 Sizes tested and results

Number of order	Number of diameters nodal <i>i</i>	Number of circles nodal <i>j</i>	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 Modeling B

4.1 Characteristics of modeling

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

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

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

4.2 Characteristics of the grid

Many nodes: 66.

Many meshes and types: 100 triangles with 3 nodes DKT

4.3 Sizes tested and results

Number of order	Number of diameter nodal <i>i</i>	Number of circles nodal <i>j</i>	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
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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 under-structuring, that it is by the method of Craig-Bampton or the method of Mac Neal, different from direct modal calculation from less 1 % .
This test validates the two methods of under-structuring.