SDLS100 - Study of meshes on a square plate mean

Abstract:

This three-dimensional problem consists in seeking the frequencies of vibration of a mechanical structure made up of a thin square plate embedded on a side. One studies the influence of the distortion of the mesh on the results. This test of Structural mechanics corresponds to a dynamic analysis of a surface model having a linear behavior. It comprises three modelizations.

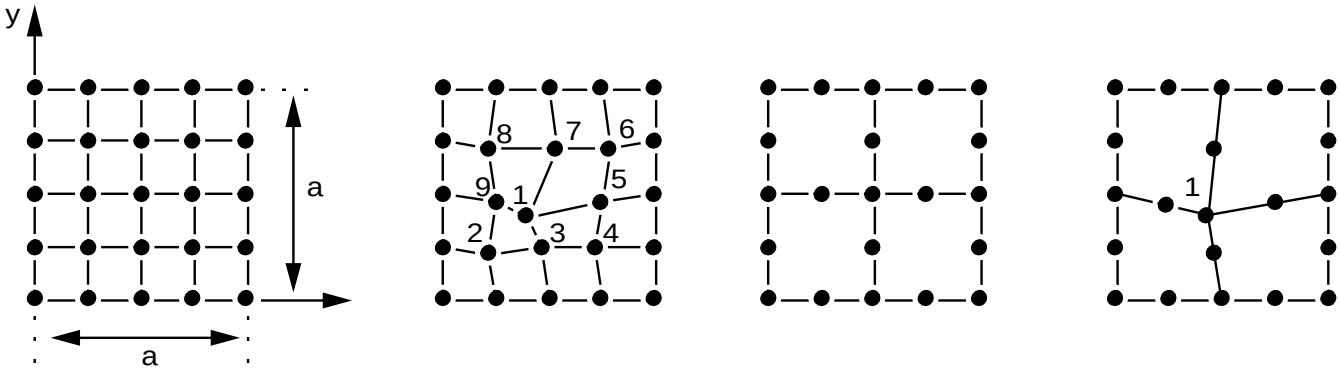
This problem makes it possible to test shell element DKT in transverse bending and the computation of the eigenfrequencies, either by the method of Lanczos, or by the method of Bathe and Wilson. The first modelization consists in netting finely and regularly the plate by triangles. For the second modelization, the mesh is coarser while for the third, it coarse and is distorted.

The first modelization is used of results as reference.

The got results are in concord between them and with those of a file NAFEMS. The effect of distortion of the mesh does not appear on the first frequencies of vibration.

1 Problem of reference

1.1 Geometry



Test 1 Test 2 Test 3 Test 4

Plates square:

side $a=10.m$

thickness $t=0.05\,m$

Coordinated of the points (in m):

Test 2			Test 4		
Node	x	y	**Node**	x	y
1.4.0.4.0			1.4.0.4.0		
2	2.25	2.25			
3	4.75	2.5			
4	7.25	2.75			
5.7.5		4.75			
6	7.75	7.25			
7	5.25	7.25			
8	2.25	7.25			
9.2.5		4.75			

1.2 Properties of the materials

$E=2.10^{11}\ Pa$

$\nu=0.3$

$\rho=8000.kg/m^3$

1.3 Boundary conditions and loadings

Any point P such as $x_p=0$: ($u=v=w=0$, $\theta_y=0$).

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 the file “Test 16” of the tests of reference published by the NAFEMS.

File NAFEMS gives the results of reference as well as computation results carried out by means of the elements of type thin shell of Kirchoff based on a formulation of isoparametric displacement quadratic (degree of freedom of rotation and normal translation to the plate).

2.2 Results of reference

the first 6 eigen modes.

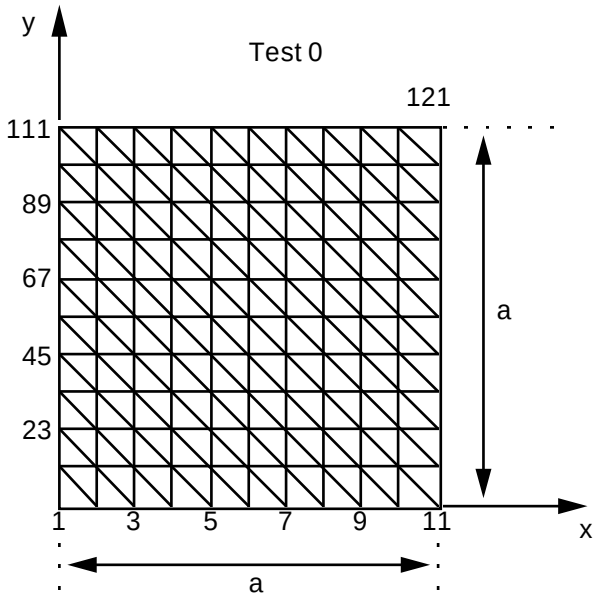
2.3 Bibliographical references

1) F. ABASSIAN, D.J. DAWSWELL, N.C. KNOWLES. Selected Benchmarks for Natural Frequency Analysis. NAFEMS (1987).

3 Modelization A

3.1 Characteristic of the modelization

fine Mesh for validation of the reference solution



Cutting:

10 on each side of the rhombus is 200 meshes TRIA3.

Slenderness of the element $\frac{a}{10\,t}=20$.

Limiting conditions:

in all the nodes P on the side $Xp=0.$:

```
DDL_IMPO: (GROUP_NO: DIMENSION  DX: 0. , DY: 0. , DZ: 0. , DRY: 0. )
```

Name of the nodes: Not 1 = $N1$
Not 121 = $N121$

3.2 Characteristic of the mesh

Many nodes:	121
Number of meshes and types:	200 TRIA3

3.3 Quantities tested and Order

results of the eigen mode	Reference Frequency (Hz)	*Aster* Frequency (Hz)	% difference
1	0.421	0.4178	– 0.8
2	1.029	1.0255	– 0.3
3	2.582	2.5669	– 0.6
4	3.306	3.2733	– 1.5
	3.753	3.7347	– 0.5
6	6.555	6.5236	– 0.5
7		7.3756	
8		7.7332	
9		8.5567	
10		11.1199	
11		11.6474	
12		14.3551	

3.4 Remarks

Computations carried out by:

```
MODE_ITER_SIMULTMETHODE    : "TRI_DIAG"
                          OPTION: ' PLUS_PETITE'NMAX_FREQ: 12
```

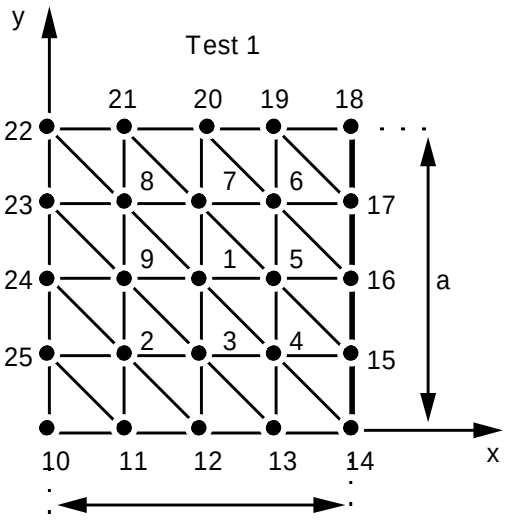
3.5 Contents of the file results

the first 12 modal eigenfrequencies, eigenvectors and parameters.

4 Modelization B

4.1 Characteristic of the modelization

Element DKT mesh coarser



Slenderness of the elements: $\frac{a}{4t}=50$.

Limiting conditions:

in all the nodes P on the side $Xp=0.$:

```
DDL_IMPO: (GROUP_NO: DIMENSION  DX: 0. , DY: 0. , DZ: 0. , DRY: 0. )
```

Name of the nodes: Not 1 = $N1$
Not 25 = $N25$

4.2 Characteristic of the mesh

Many nodes:	25
Number of meshes and types:	32 TRIA3

4.3 Quantities tested and Frequency

results (Hz)

Order of the eigen mode	Reference	Test NAFEMS	*Aster*	% difference
	NAFEMS			
1	0.421	0.4174	0.4165	– 1.07
2	1.029	1.020	1.0301	0.11
3	2.582	2.564	2.5793	– 0.10
4	3.306	3.302	3.2572	– 1.47
5	3.753	3.769	3.7397	– 0.35
6	6.555	6.805	6.4544	– 1.54
	Test 0			
7	7.3756		7.2821	– 1.27
8	7.7332		7.6852	– 0.62
9	8.5567		8.3764	– 2.11
10	11.1199		10.7209	– 3.59
11	11.6474		11.2904	– 3.06
12	14.3531		13.7573	– 4.16

4.4 Remarks

Computations carried out by:

```
MODE_ITER_SIMULTMETHODE    : "JACOBI"
                          OPTION: ' PLUS_PETITE'NMAX_FREQ: 12
```

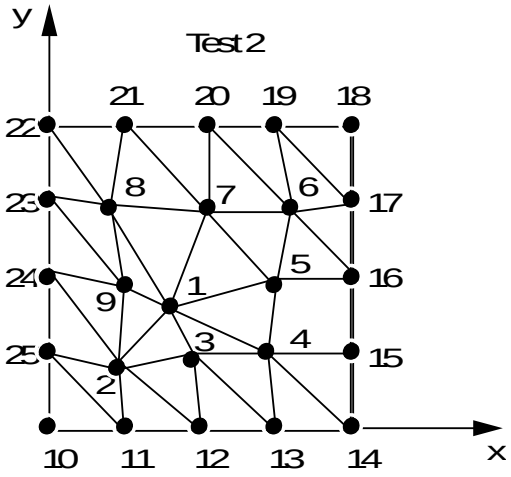
4.5 Contents of the file results

the first 12 modal eigenfrequencies, eigenvectors and parameters.

5 Modelization C

5.1 Characteristic of the modelization

Element DKT with mesh distorted



Slenderness of the element: between 50 and 75.

Limiting conditions:

in all the nodes P on the side $Xp=0.$:

```
DDL_IMPO: (GROUP_NO: DIMENSION  DX: 0. , DY: 0. , DZ: 0. , DRY: 0. )
```

Name of the nodes: Not 1 = $N1$
Not 25 = $N25$

5.2 Characteristic of the mesh

Many nodes:	25
Number of meshes and types:	32 TRIA3

5.3 Quantities tested and Frequency

results (Hz)

Order of the eigen mode	Reference	Test NAFEMS	*Aster*	% difference
	NAFEMS			
1	0.421	0.4174	0.4163	– 1.12
2	1.029	1.020	1.0340	0.49
3	2.582	2.571	2.5644	– 0.68
4	3.306	3.317	3.2539	– 1.58
5	3.753	3.780	3.7433	– 0.26
6	6.555	6.883	6.4898	– 0.99
	Test 0			
7	7.3756		7.2119	– 2.22
8	7.7332		7.6026	– 1.69
9	8.5567		8.3232	– 2.73
10	11.1199		10.7735	– 3.12
11	11.6474		11.2607	– 3.32
12	14.3531		13.3008	– 7.34

5.4 Remarks

Computations carried out by:

```
MODE_ITER_SIMULTMETHODE    : "TRI_DIAG"
                          OPTION: ' PLUS_PETITE'NMAX_FREQ: 12
```

5.5 Contents of the file results

the first 12 modal eigenfrequencies, eigenvectors and parameters.

6 Summary of the results

% differences/reference

Order of the eigen mode	Reference NAFEMS	*Aster* Test 0	*Aster* Test 1	*Aster* Test 2%	diff. Test 0%	diff. Test 1%	diff. Test 2
1	0.421	0.4178	0.4165	0.4163	– 0.76	– 1.07	– 1.12
2	1.029	1.0255	1.0301	1.0340	– 0.34	0.11	0.49
3	2.582	2.5669	2.5793	2.5644	– 0.58	– 0.10	– 0.68
4	3.306	3.2733	3.2572	3.2539	– 0.99	– 1.47	– 1.58
5	3.753	3.7347	3.7397	3.7433	– 0.49	– 0.35	– 0.26
6	6.555	6.5236	6.4544	6.4898	– 0.48	– 1.54	– 0.99%

differences/reference

Order of the eigen mode	Reference NAFEMS	*Aster* Test 0	*Aster* Test 1	*Aster* Test 2%	diff. Test 0%	diff. Test 1%	diff. Test 2
7		7.3756	7.2821	7.2119		– 1.27	– 2.22
8		7.7332	7.6852	7.6026		– 0.62	– 1.69
9		8.5567	8.3764	8.3232		– 2.11	– 2.73
10		11.1199	10.7209	10.7735		– 3.59	– 3.12
11		11.6474	11.2904	11.2607		– 3.07	– 3.32
12		14.3551	13.7573	13.3008		– 4.16	– 7.34

- For tests 1 and 2, the quadrangles of file NAFEMS were cut out in triangles.
- Tests 3 and 4 can be carried out by *Aster* (not of quadratic element of shell).
- Until the 9th mode, the error on the frequency is $\leq 2.5\%$.
- The effect of distortion of the mesh appears really only on modes 7 and 12.