
SDLS502 - Square plate “solid” simply supported

Summarized:

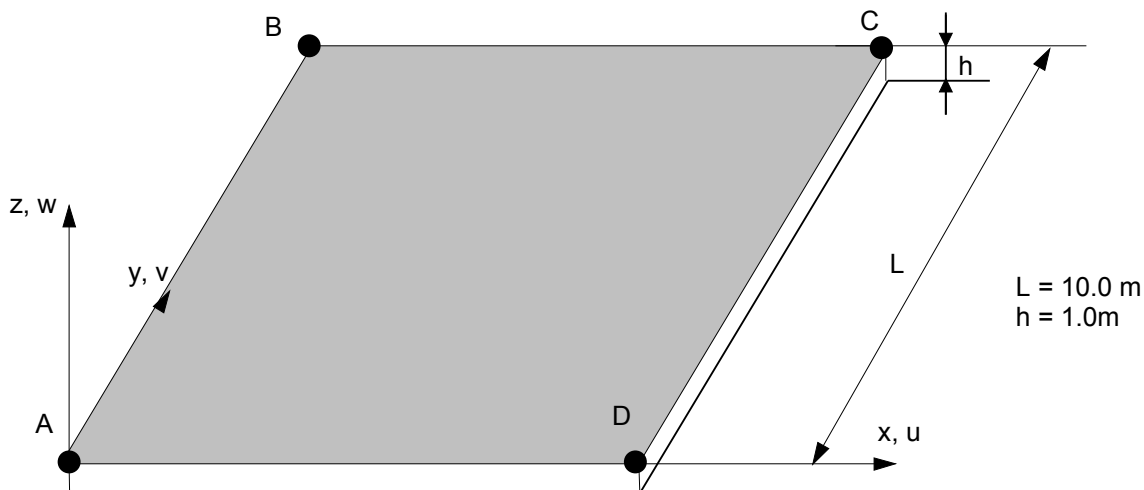
This test represents a computation in dynamic modal analysis of a thick square plate simply supported. This test makes it possible to validate:

the modelizations finite elements `DST`, `DKT`, `COQUE_3D` with meshes `QUAD4` and `TRIA3`, `QUAD8` and `TRIA6`, and 3D with meshes `HEXA20`,
the taking into account of the stiffness in transverse shears.

The frequencies and the modes obtained are compared with a reference solution, suggested by NAFEMS, obtained with a computation finite elements of the voluminal type.

1 Problem of reference

1.1 Geometry



1.2 Properties of the material

the properties of the material constituting the plate are:

$$\begin{aligned} E &= 2.10^{11} && \text{Pa Modulus Young} \\ \nu &= 0.3 && \text{Poisson's ratio} \\ \rho &= 8000. \text{kg/m}^3 && \text{Density} \end{aligned}$$

1.3 Boundary conditions and loadings

Plates simply supported on its contour.

1.4 Initial conditions

Without Reference solution

2 object

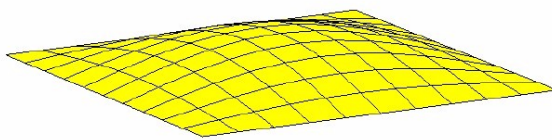
2.1 Method of calculating used for the reference solution

the reference solution suggested by NAFEMS [bib1] was obtained to leave a computation finite elements 3D with elements bricks to 20 nodes and with a mesh 4×4 (plane xy) and 1 element following the thickness.

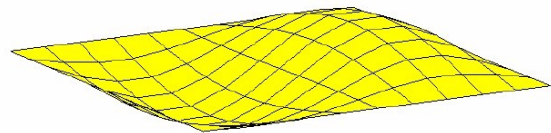
2.2 Results of reference

the first 7 non-zero frequencies and the associated eigen modes, the first three modes are those of rigid bodies:

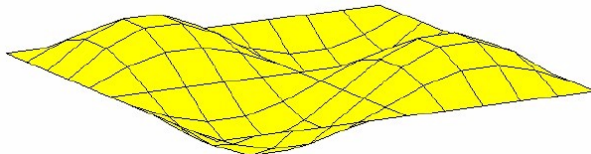
Frequency (mode 4 except plane)	:	44.762 hz
Frequency (modes 5 & 6 except plane)	:	110.52 hz
Frequency (mode 7 except plane)	:	169.08 hz
Frequency (Mode 8 in the plane)	:	193.93 hz
Frequency (mode 9 & 10 in the plane)	:	206.64 hz



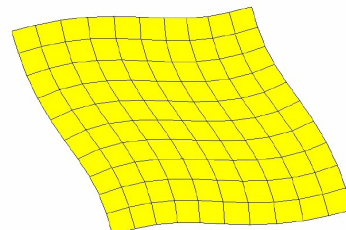
mode 4 out plane



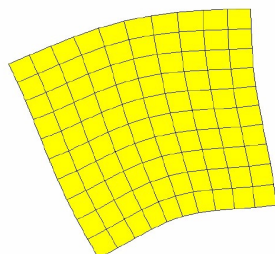
5&6 mode out plane



mode 7 out plane



mode 8 in the plane



9&10 mode in the Uncertainties

2.3 plane on the solution

< 2% for a mesh identical to that of [2.1], i.e. with few elements.

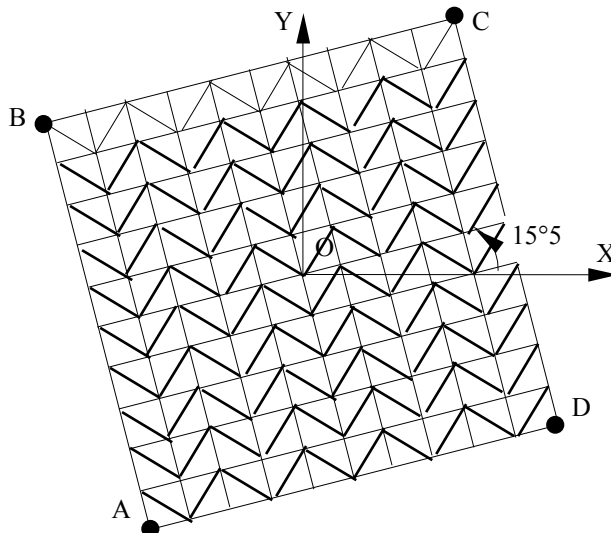
2.4 Bibliographical references

Warning : The translation process used on this website is a "Machine Translation". It may be imprecise and inaccurate in whole or in part and is provided as a convenience.

1.NAFEMS: Standard The NAFEMS Benchmarks, TNSB, rev. 3, October 5th, 1990.

3 Modelization A

3.1 Characteristic of the modelization



Modélisation DST (TRIA3)

- La plaque est située dans le plan $Z = 2.3$
- Point O : (0. ;0. ;2.3)

Conditions aux limites :

- Cotés AB, BC, CD, DA : $w=0$

to validate the modelization in a reference different from the total reference, the plate is turned of $15,5^\circ$. This should not change the eigenfrequencies obtained.

3.2 Characteristics of the mesh

Many nodes: 122
Number of meshes and types: 200 TRIA3

3.3 Quantities tested and results

Identification	Times	Reference	Aster	% difference
Frequency (mode 4 except plane)		44.762	44.989	0.507
Frequency (modes 5 & 6 except plane)		110.52	107.608	- 2.634
Frequency (mode 7 except plane)		169.08	165.454	- 2.144
Frequency (Mode 8 in the plane)		193.93	196.089	1.114
Frequency (mode 9 & 10 in the plane)		206.64	211.658	2.428
			212.000	2.594

3.4 Remarks

In Aster, the calculated modes are those of rigid body: the fourth mode of reference is the first mode calculated by *Code_Aster*.

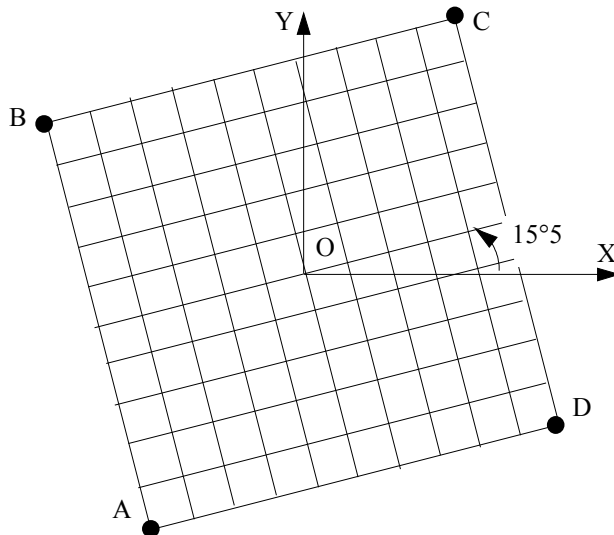
Appearance of two modes of bending enters modes 8 and 9 of reference: these modes are modes 6 and 7 of *Code_Aster*.

In the table below we deferred the first 14 found eigenfrequencies.

Mode n°	Frequency (Hz)
1	44,98
2	107.61
3	107.88
4	165.45
5	196.09
6	202.80
7	203.54
8	211.66
9	212.00
10	222.53
11	254.74
12	255.62
13	264.73
14	289.85

4 Modelization B

4.1 Characteristic of the modelization



Modélisation DST (QUAD4)

- La plaque est située dans le plan $Z = 2.3$
- Point O : (0. ; 0. ; 2.3)

Conditions aux limites :

- Cotés AB, BC, CD, DA : $w=0$

to validate the modelization in a reference different from the total reference, the plate is turned of $15,5^\circ$. This should not change the eigenfrequencies obtained.

4.2 Characteristics of the mesh

Many nodes: 122

Number of meshes and types: 100 QUAD4

4.3 Quantities tested and results

Identification	Times	Reference	Aster	% difference
Frequency (mode 4 except plane)		44.762	44.64	- 0.273
Frequency (modes 5 & 6 except plane)		110.52	108.04 108.26	- 2.247 - 2.041
Frequency (mode 7 except plane)		169.08	162.86	- 3.681
Frequency (Mode 8 in the plane)		193.93	195.70	0.912
Frequency (mode 9 & 10 in the plane)		206.64	208.89 208.89	1.088

4.4 Remarks

In Code_Aster, the calculated modes are those of rigid body: the fourth mode of reference is the first mode calculated by Code_Aster.

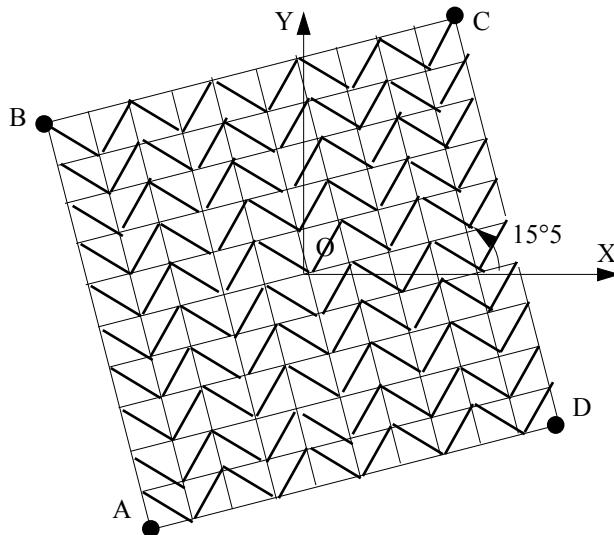
Appearance of two modes of bending enters modes 8 and 9 of reference: these modes are modes 6 and 7 of Code_Aster.

In the table below we deferred the first 14 found eigenfrequencies.

Mode n°	Frequency (Hz)
1	44.64
2	108.04
3	108.26
4	162.86
5	195.70
6	203.97
7	206.08
8	208.89
9	208.89
10	220.92
11	248.12
12	250.10
13	252.49
14	289.79

5 Modelization C

5.1 Characteristic of the modelization



Modélisation DKT (TRIA6)

- La plaque est située dans le plan $Z = 2.3$
- Point O : (0. ; 0. ; 2.3)

Conditions aux limites :

- Cotés AB, BC, CD, DA : $w=0$

to validate the modelization in a reference different from the total reference, the plate is turned of $15,5^\circ$. This should not change the eigenfrequencies obtained.

5.2 Characteristics of the mesh

Many nodes: 122

Number of meshes and types: 200 TRIA3

5.3 Quantities tested and results

Identification	Times	Reference	Aster	% difference
Frequency (mode 4 except plane)		44.762	47.358	5.799
Frequency (modes 5 & 6 except plane)		110.52	118.029 118.059	6.795 6.822
Frequency (mode 7 except plane)		169.08	187.504	10.897
Frequency (Mode 8 in the plane)		193.93	196.089	1.114
Frequency (mode 9 & 10 in the plane)		206.64	211.658 212.000	2.428 2.594

5.4 Remarks

In Aster, the calculated modes are those of rigid body: the fourth mode of reference is the first mode calculated by *the Code_Aster*.

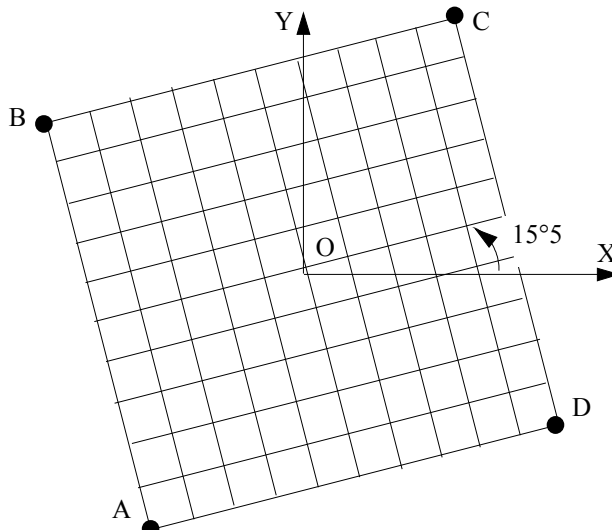
Appearance of two modes of bending after mode 11 of reference (mode 8 of *the Code_Aster*), of the same form as those appeared in modelization DST enters modes 8 and 9 of reference (modes 6 and 7 of *the Code_Aster*).

In the table below we deferred the first 14 found eigenfrequencies.

Mode n°	Frequency (Hz)
1	47.358
2	118.03
3	118.06
4	187.50
5	196.09
6	211.66
7	212.00
8	222.53
9	235.41
10	235.56
11	264.73
12	289.85
13	302.84
14	303.15

6 Modelization D

6.1 Characteristic of the modelization



Modélisation DKT (QUAD4)

- La plaque est située dans le plan $Z = 2.3$
- Point O : (0. ; 0. ; 2.3)

Conditions aux limites :

- Cotés AB, BC, CD, DA : $w=0$

to validate the modelization in a reference different from the total reference, the plate is turned of $15,5^\circ$. This should not change the eigenfrequencies obtained.

6.2 Characteristics of the mesh

Many nodes: 122

Number of meshes and types: 100 QUAD4

6.3 Quantities tested and results

Identification	Times	Reference	Aster	% difference
Frequency (mode 4 except plane)		44.762	47.182	5.408
Frequency (modes 5 & 6 except plane)		110.52	117.463	6.283
Frequency (mode 7 except plane)		169.08	184.746	9.266
Frequency (Mode 8 in the plane)		193.93	195.699	0.912
Frequency (mode 9 & 10 in the plane)		206.64	208.887	1.088

6.4 Remarks

In Aster, the calculated modes are those of rigid body: the fourth mode of reference is the first mode calculated by *Code_Aster*.

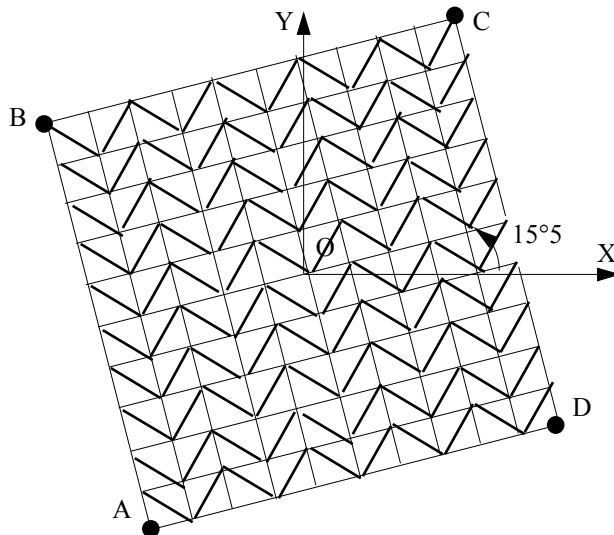
Appearance of two modes of bending after mode 11 of reference (mode 8 of *Code_Aster*), of the same form as those appeared in modelization *DST* enters modes 8 and 9 of reference (modes 6 and 7 of *Code_Aster*).

In the table below we deferred the first 14 found eigenfrequencies.

Mode n°	Frequency (Hz)
1	47.183
2	117.46
3	117.46
4	184.75
5	195.70
6	208.89
7	208.89
8	220.92
9	234.74
10	234.74
11	252.49
12	289.79
13	297.27
14	297.27

7 Modelization E

7.1 Characteristic of the modelization



Modélisation COQUE_3D (TRIA6)

- La plaque est située dans le plan $Z = 2.3$
- Point O : (0. ; 0. ; 2.3)

Conditions aux limites :

- Cotés AB, BC, CD, DA : $w=0$

to validate the modelization in a reference different from the total reference, the plate is turned of $15,5^\circ$. This should not change the eigenfrequencies obtained.

7.2 Characteristics of the mesh

Many nodes: 122

Number of meshes and types: 200 TRIA6

7.3 Quantities tested and results

Identification	Times	Reference	Aster	% difference
Frequency (mode 4 except plane)		44.762	43.867	2.00
Frequency (modes 5 & 6 except plane)		110.52	106.058 106.066	- 4.037 - 4.029
Frequency (mode 7 except plane)		169.08	160.010	- 5.305
Frequency (Mode 8 in the plane)		193.93	193.600	- 0.170
Frequency (mode 9 & 10 in the plane)		206.64	206.209 206.211	0.208 0.207

7.4 Remarks

In Aster, the calculated modes are those of rigid body: the fourth mode of reference is the first mode calculated by *Code_Aster*.

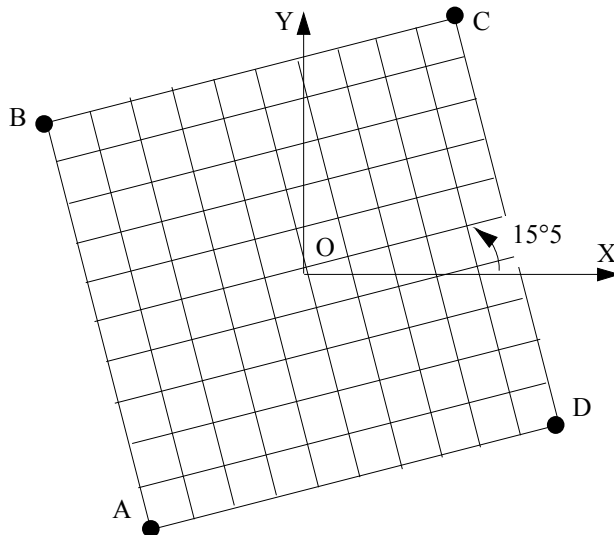
Appearance of two modes of bending enters modes 8 and 9 of reference: they are modes 6 and 7 of *Code_Aster*.

In the table below we deferred the first 14 found eigenfrequencies.

Mode n°	Frequency (Hz)
1	43,867
2	106.06
3	106.07
4	160.11
5	186,72
6	193.60
7	199.76
8	200.23
9	206.21
10	206.21
11	219.28
12	245.91
13	245.94
14	249.27

8 Modelization F

8.1 Characteristic of the modelization



Modélisation COQUE_3D (QUAD8)

- La plaque est située dans le plan $Z = 2.3$
- Point O : (0. ; 0. ; 2.3)

Conditions aux limites :

- Cotés AB, BC, CD, DA : $w=0$

to validate the modelization in a reference different from the total reference, the plate is turned of $15,5^\circ$. This should not change the eigenfrequencies obtained.

8.2 Characteristics of the mesh

Many nodes: 122
Number of meshes and types: 100 QUAD8

8.3 Quantities tested and results

Identification	Times	Reference	Aster	% difference
Frequency (mode 4 except plane)		44.762	43.870	- 1.993
Frequency (modes 5 & 6 except plane)		110.52	106.041	- 4.052
Frequency (mode 7 except plane)		169.08	160.055	- 5.337
Frequency (Mode 8 in the plane)		193.93	193.588	- 0.176
Frequency (mode 9 & 10 in the plane)		206.64	206.192	- 0.216

8.4 Remarks

In *Code_Aster*, the calculated modes are those of rigid body: the fourth mode of reference is the first mode calculated by *Code_Aster*.

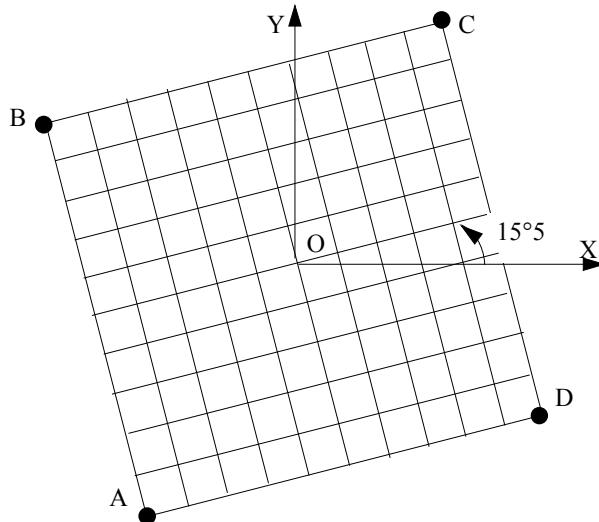
Appearance of two modes of bending enters modes 8 and 9 of reference: they are modes 6 and 7 of *Code_Aster*.

In the table below we deferred the first 14 found eigenfrequencies.

Mode n°	Frequency (Hz)
1	43.87
2	106.04
3	106.04
4	160.06
5	193.59
6	199.64
7	200.13
8	206.19
9	206.19
10	219.26
11	245.68
12	245.68
13	249.20
14	287.99

9 Modelization G

9.1 Characteristic of the modelization

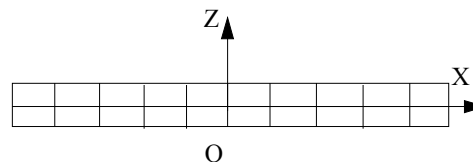


Modélisation 3D (HEXA20)

- Le plan moyen de la plaque est situé dans le plan $Z = 2.3$
- Point O : (0. ; 0. ; 2.3)

Conditions aux limites :

- Cotés AB, BC, CD, DA : $w=0$



9.2 Characteristics of the mesh

Many nodes: 1266
Number of meshes and types: 200 HEXA20

9.3 Quantities tested and results

Identification	Times	Reference	Aster	% difference
Frequency (mode 4 except plane)		44.762	43.862	- 2.009
Frequency (modes 5 & 6 except plane)		110.52	105.953	- 4.132
Frequency (mode 7 except plane)		169.08	159.749	- 5.518
Frequency (Mode 8 in the plane)		193.93	193.590	- 0.175
Frequency (mode 9 & 10 in the plane)		206.64	199.410 199.903	- 3.498 - 3.260

9.4 Remarks

In *Code_Aster*, the calculated modes are those of rigid body: the fourth mode of reference is the first mode calculated by *Code_Aster*.

Appearance of two modes of bending enters modes 8 and 9 of reference: they are modes 6 and 7 of *the Code_Aster*.

In the table below we deferred the first 14 found eigenfrequencies.

Mode n°	Frequency (Hz)
1	43.86
2	105.95
3	105.95
4	159.75
5	193.59
6	199.41
7	199.90
8	206.16
9	206.16
10	219.27
11	245.07
12	245.07
13	249.13
14	287.75

10 Summary of the results

Taking into account the nature of the numerical solution (voluminal finite elements), the got results are satisfactory for:

modelization A and B (DST) the maximum change is of less 4% for the first 5 modes,
modelization E and F (COQUE_3D), the maximum change is of approximately 5% for the first 5 modes,
modelization G (3D), the maximum change is of approximately 5% for the first 5 modes,
the modes of reference 5 and 6 except plane have symmetry different from those met in the modelizations E, F and G, but they are equivalent because they are modal recombinations.

The modelizations C and D (DKT) are less satisfactory with relative variations reaching 10% on mode 7 except plane, this due to is not taken into account of the transverse shears for this relatively thick plate. Moreover one observes the appearance of modes of bending and membrane for all these modelizations, including the modelization 3D voluminal G. When one refines sufficiently the meshes, this tendency is confirmed relative variations and the regress. The computation 3D in addition showed that in on this side mesh 6×6 in the plane (XY), the modes of bending and membrane were not detected.