SSLV139 - Buckling of a circular plate subjected to a compression force uniformly distributed on its Summarized

contour:

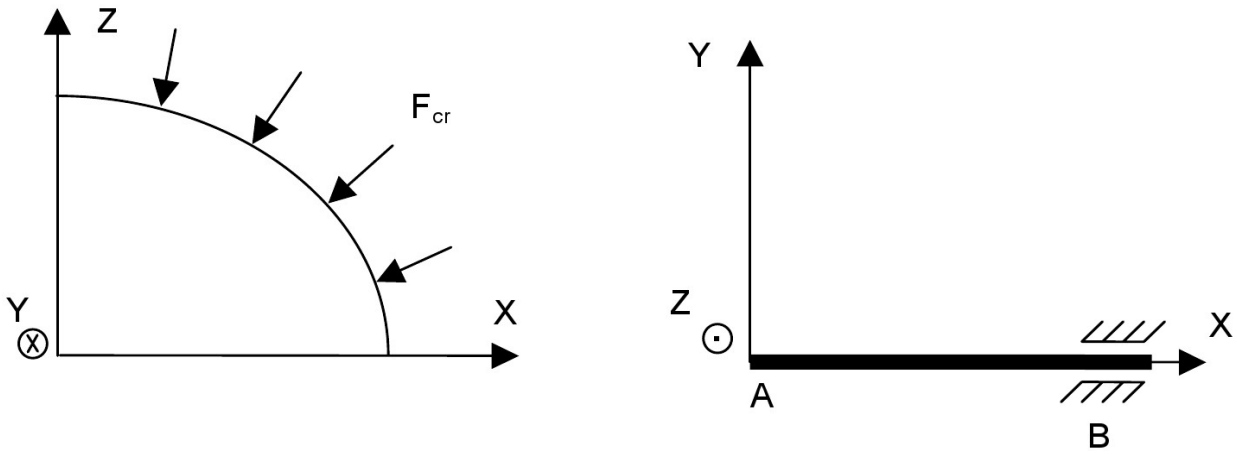
This test represents a computation of stability of a circular plate subjected to a compression force uniformly distributed on its contour. We determine the critical load leading to the elastic buckling of Eulerian as well as the associated modal deformed shape.

This test validates modelization AXIS_FOURIER for linear buckling with meshes QUAD8 and TRIA6 (circumferential mode equal to zero), and modelization AXIS with meshes QUAD8.

The critical load obtained is compared with an analytical reference solution.

1 Problem of reference

1.1 Geometry



Thickness of the plate: $h=0.0005\,m$
Radius of the plate : $R=0.115\,m$

1.2 Properties of the material

the properties of the material constituting the plate are:

$E=2.1\,10^{11}\,Pa$	Young's modulus
$\nu=0.3$	Poisson's ratio

1.3 Boundary conditions and loadings

Boundary conditions:

on the contour of the plate (not B): following displacement $Y=0$ and rotation around $Z=0$

Loading: one applies a compression force uniformly distributed F to the external contour of the plate.

1.4 Initial conditions

Without object.

2 Reference solution

2.1 Method of calculating

the value of the critical load is given in [bib1] by the following statement:

$$F_{cr} = \frac{14.68\, D}{R^2}$$

with: D the bending stiffness of the plate (in $N.m$) defined by the following statement:

$$D = \frac{E\, h^3}{12\,(1-\nu^2)}$$

This critical load is associated with a circumferential mode equal to 0.

2.2 Quantities and results of reference

For the characteristics given, the critical load is worth:

$F_{cr} = 2668.315\, N/m$

2.3 Uncertainties on the analytical

solution Solution

2.4 bibliographical References

1) S.P. TIMOSHENKO, J.M. MANAGES: Theory of elastic stability, second edition, DUNOD (1966)

3 Modelization A

3.1 Characteristic of the modelization

Modelization AXIS_FOURIER (QUAD8): 3 degrees of freedom per node (DX, DY, DZ)

limiting Conditions:
mesh group AD : $DX=0, DZ=0$
mesh group BC : $DY=0, DZ=0$

Characteristics of the discretization
Sides AB and CD : 460 elements
Sides AD and BC : 4 elements

3.2 Characteristic of the mesh

Many nodes: 6449
Number of meshes: 1840 (QUAD8)

3.3 Quantities tested and results

Identification	critical
Reference Pressure ($n=0$)	$8.4935\,10^5\,Pa$
Displacement DY with the node D	1

3.4 Remarks

the critical pressure P_{cr} of reference, used in the command file, were obtained from the critical load referred in the paragraph [§2.22.2]:

$$P_{cr}=\frac{F_{cr}}{2\pi h}=849350.94\,N/m^2$$

The standardization of the eigen mode for largest of the components of translation implies a value of reference equal to 1 for displacement DY to the node D.

4 Modelization B

4.1 Characteristic of the modelization

Modelization AXIS (QUAD8): 2 degrees of freedom per node (DX, DY)

limiting Conditions:
mesh group AD : $DX=0$
mesh group BC : $DY=0$

Characteristics of the discretization
Sides AB and CD : 460 elements
Sides AD and BC : 4 elements

4.2 Characteristic of the mesh

Many nodes: 6449
Number of meshes: 1840 (QUAD8)

4.3 Quantities tested and results

Identification	Reference
Pressure criticize ($n=0$)	$8.4935\,10^5\,Pa$
Displacement DY with node D	1

4.4 Remarks

the critical pressure P_{cr} of reference, used in the command file, were obtained from the critical load referred in the paragraph [§2.22.2]:

$$P_{cr}=\frac{F_{cr}}{2\pi h}=849350.94\,N/m^2$$

The standardization of the eigen mode for largest of the components of translation implies a value of reference equal to 1 for displacement DY to the node D.

5 Modelization C

5.1 Characteristic of the modelization

Modelization AXIS_FOURIER (TRIA6): 3 degrees of freedom per node (DX, DY, DZ)

limiting Conditions:
mesh group AD : $DX=0$, $DZ=0.$
mesh group BC : $DY=0$, $DZ=0.$

Characteristic of the discretization
Sides AB and CD : 690 elements
Sides AD and BC : 6 elements

5.2 Characteristic of the mesh

Many nodes: 17.964
Number of meshes: 8.280 (TRIA6)

5.3 Quantities tested and results

Identification	critical
Reference Pressure ($n=0$)	$8.4935\,10^5\,Pa$
Displacement DY with the nœudformule D	1

5.4 Remarks

the critical pressure P_{cr} of reference, used in the command file, was got from the critical load referred in the paragraph [§2.22.2]:

$$P_{cr}=\frac{F_{cr}}{2\pi h}=849350.94\,N/m^2$$

The standardization of the eigen mode for largest of the components of translation implies a value of reference equal to 1 for displacement DY to the node D.

6 Summary of the results

the got results are very satisfactory for meshes the QUAD8 independently of the modelization used (AXIS or AXIS_FOURIER) : uncertainties on the critical pressure do not exceed 0.104%.

However, it will be noted that modelization AXIS_FOURIER is definitely less precise with meshes TRIA6 than with meshes QUAD8.

This test with license to test and compare modelizations AXIS and AXIS_FOURIER in linear buckling of Eulerian of a circular thin structure subjected to an external force of compression uniformly distributed on its contour.