

RamSeries - Validation Case 33

Shell buckling



RamSeries

Version
15.1.0

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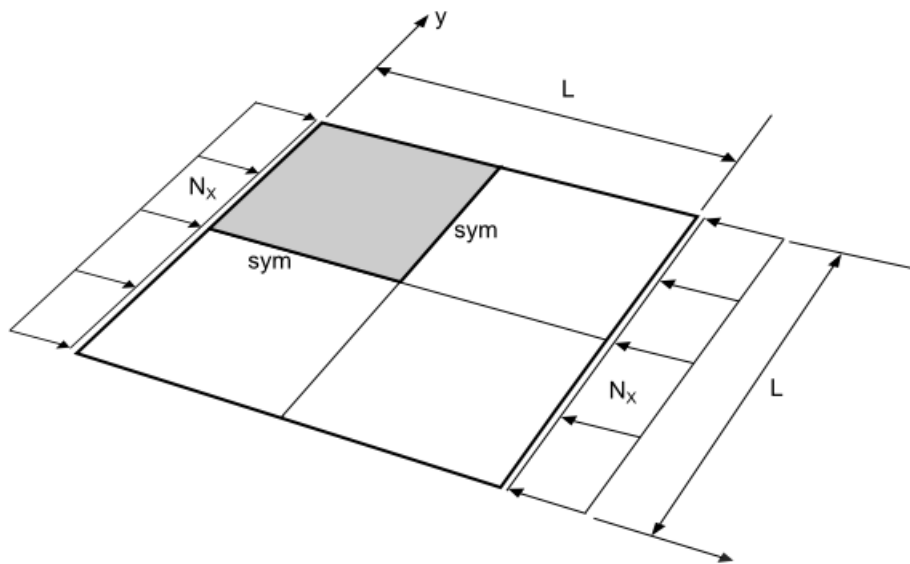
1 Validation Case 33 - Shell Linearized Buckling

Model description

This test case is based on the example "Buckling analysis of square plate compressed in one direction" described in Ref. [1]. In the aforementioned example, the buckling of a square plate subjected to in-plane uniaxial compression is considered.

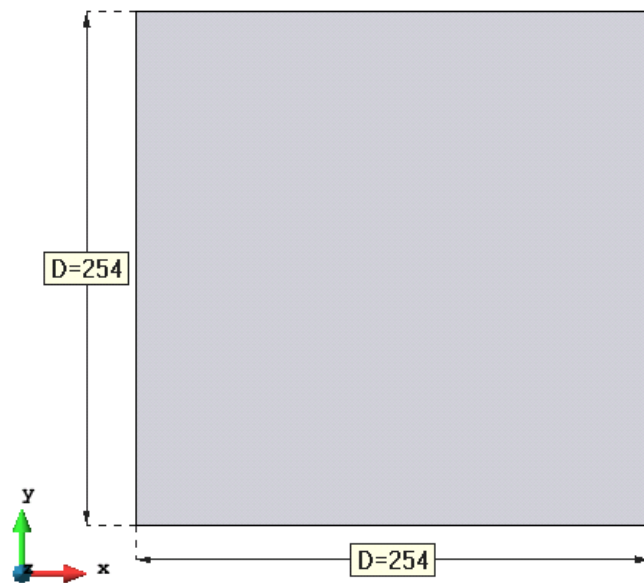
Geometry model

In the following figure, the geometry of the model is shown.



$L=508 \text{ mm}$

Only a quarter of the model has been modeled to apply symmetry conditions proposed in the example.



Material properties

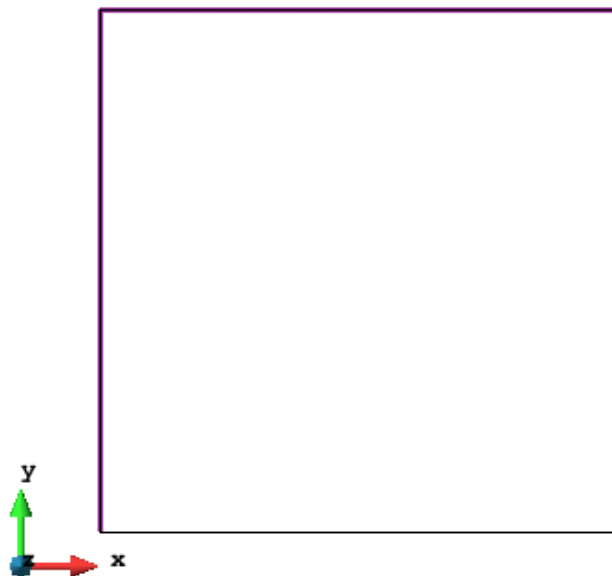
E (Young's modulus) = 2.062×10^5 N/mm²

ν (Poisson's ratio) = 0.3

Thickness = 3.175 mm

Constraints

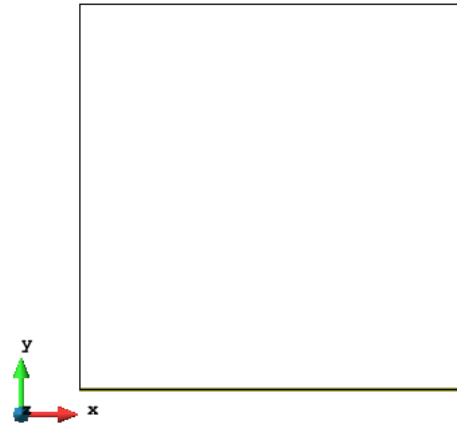
Since the plate is simply supported along all edges, the edges shown in the next figure, must have Z direction fixed.



For applying symmetry condition, the following constraints must be added:

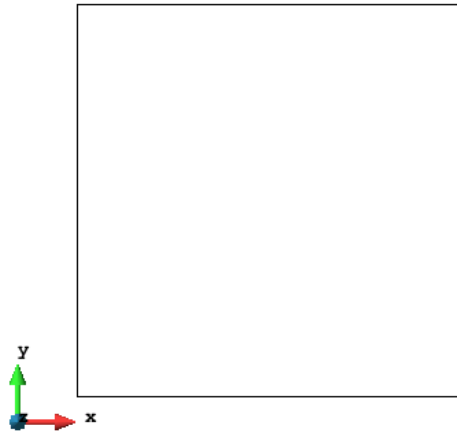
Fixed degrees:

- Y
- X rotation
- Z rotation



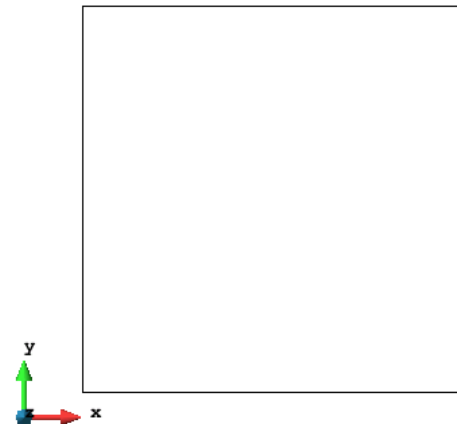
Fixed degrees:

- X
- Y rotation
- Z rotation



Fixed degrees:

- X
- Y
- X rotation
- Y rotation
- Z rotation



Buckling parameters:

In this example, only the first three modes will be checked, so Buckling data -> Num. of buckling modes = 3.

On the other hand, an Imperfections factor = 0.0.

Results

Analytical results

According to the Reference 1, the critical value of the compressive force per unit length (Nx) can be calculated with the following equation:

$$N_x = \frac{\pi^2 D}{L^2} \left(m + \frac{1}{m} \right)^2$$

where $D = (Et^3)/(12(1 - \nu^2))$

where

- L is plate side length (508 mm)
- t is the plate thickness (3.175 mm)
- ν is Poisson's ratio (0.3)
- E is Young's modulus (2.062e5 N/mm²)
- m is the number of half-waves in the compressive direction. The buckling modes are associated with odd values of m.

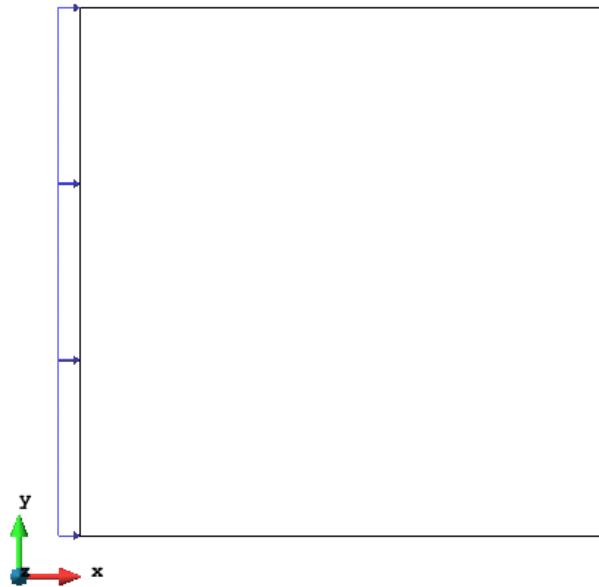
The critical value of the compressive force according the previous equation is 92.45 N/mm.

Numerical results

For the sake of validation, a simulation was run using the properties described in the previous section.

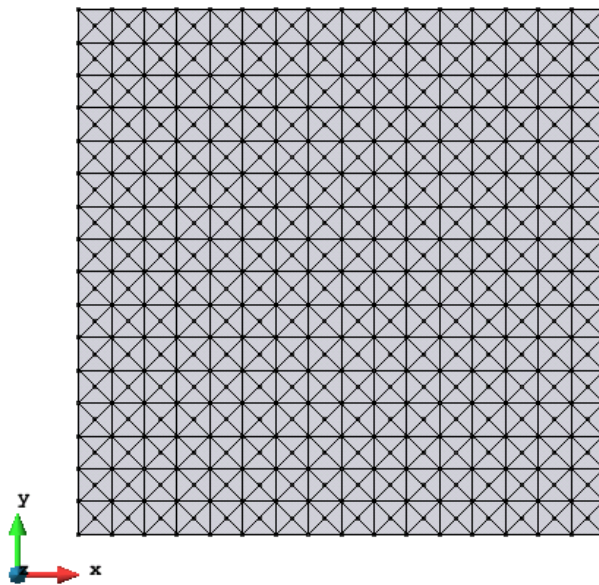
Load

A compressive force equal to the critical value (92.45 N/mm) has been applied as the next figure shown:



Mesh

A structural mesh of triangles with 16 cells for each edge has been used to performance the numerical analysis.

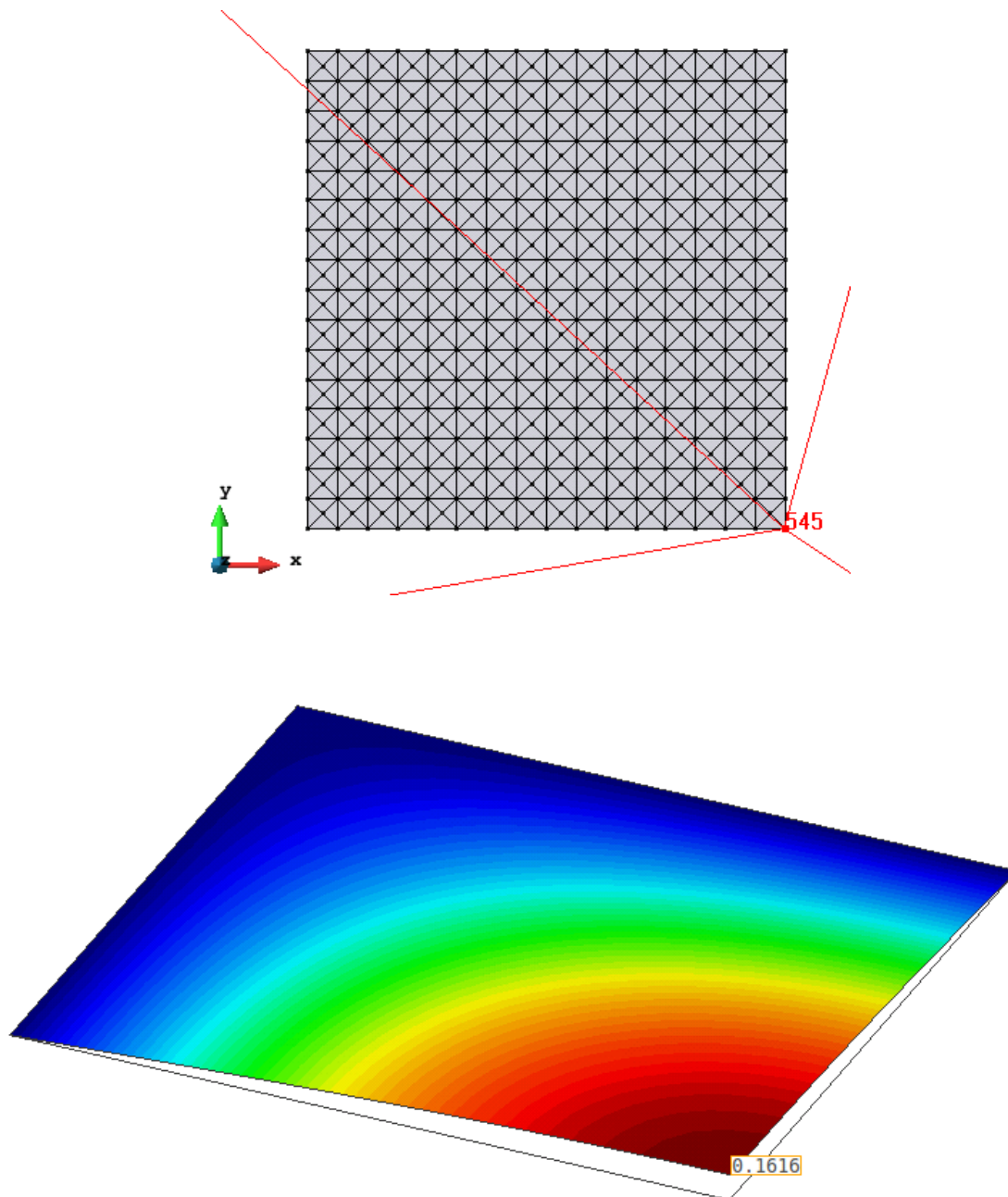


Results

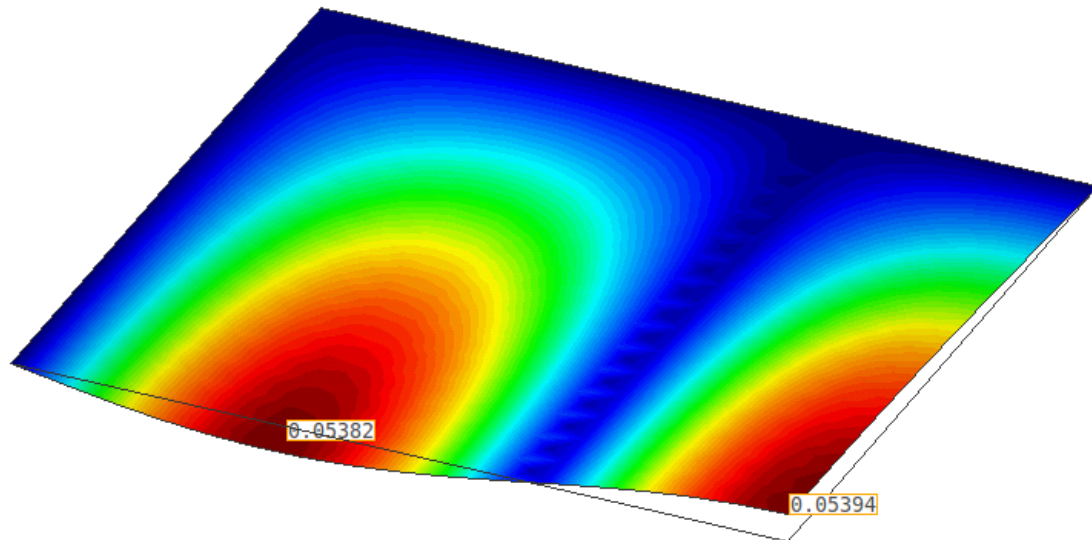
Next, the three first critial factors ($m=1,3,5$) obtained in the simulation, are compared with the analitical results:

Analytical factor	Simulation results	% Error
1.000	1.001	0.1
2.778	2.785	0.25
6.760	6.8	0.59

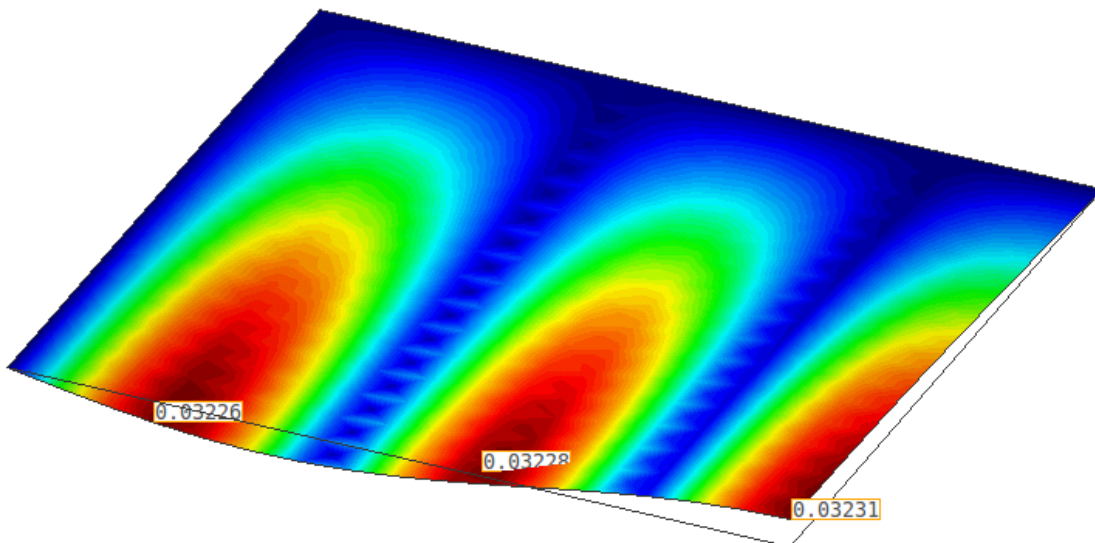
Finally, the results of the first modes and the displacement of node 545 are shown:



Mode 1: m=1. Displacement(node 545) = 0.1616 m



Mode 2: $m=3$. Displacement(node 545) = 0.05394 m



Mode 3: $m=5$. Displacement(node 545) = 0.03231

References

[1] B. Haugen: Buckling and stability problems for thin shell structures using high performance finite elements. University of Colorado, 1991, p, 113.

Validation Summary

CompassFEM version	15.1.0
Tdyn solver version	15.1.0
RamSeries solver version	15.1.0
Benchmark status	Successfull
Last validation date	27/11/2018