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RamSeries - Valididation Case 5

Cantilever beam under self weight

RamSeries

Version
15.1.0

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November 2018

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1 Cantilever beam under self weight

Model description

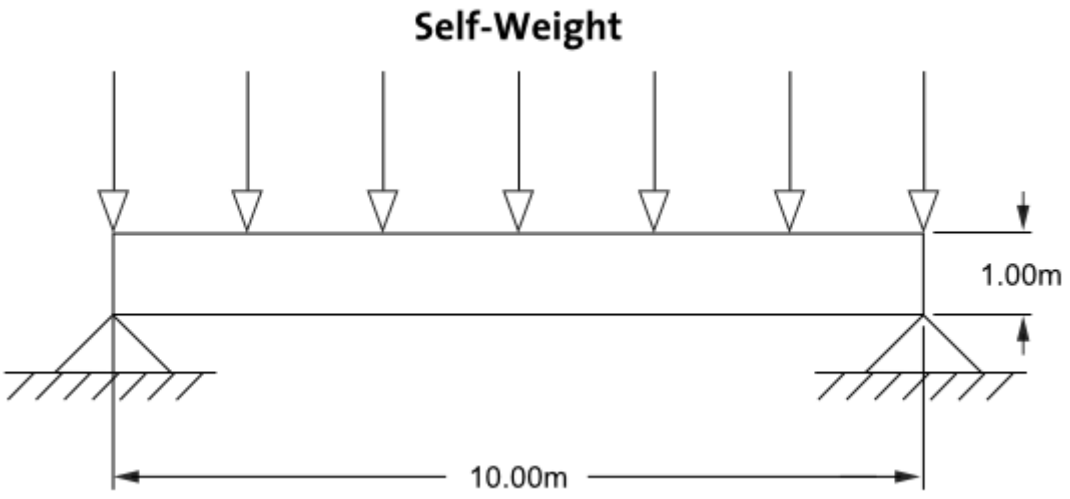
This validation example shows the analysis of a simply supported thick cantilever beam under self weight load. Results for different density meshes of 3-noded triangles and 4-noded quadrilaterals are compared against the exact analytical solution. Results are also compared with the solution given for quadratic elements, both triangles and rectangles (6 and 8 nodes, respectively).

For the sake of comparison, the vertical deflection δ_y of the center of the free end (point A) and the axial stress $\sigma_x$at the lower fibre of the middle section (point B) are examined.

Geometrical model:

The rectangular cantilever beam geometry is defined as follows:

	Point 1	Point 2	Point 3	Point 4
x	0	10	10	0
y	0	0	1	1
z	0	0	0	0



FEM model setup:

- Boundary conditions:
  Two simply supported points, with only the vertical displacement restrained:

  P1 (0,0,0)

  P2 (10,0,0)

- Loads:
  The only load applied is the self-weight of the cantilever beam, which is dependent on its specific weight, detailed below (Material properties).

- Material:
  Cantilever beam properties are the following:

  Thickness (t): 0.1 m

  E: 2.0e8 Pa

  v: 0.2

  η: 4000 N/m^3

Results

The exact analytical solution, given in [1]is:

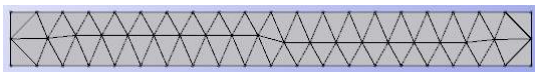
δ_{Ay} = -0.032153 m

σ_{Bx} = 3.0e5 Pa

Convergence of the vertical deflection (δ_y) and horizontal stress (σ_x) at the center of the lower fiber is presented here as a function of the number of nodes for unstructured meshes of 3-noded triangles and 4-noded rectangles.

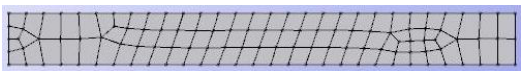
62 nodes, 78 elems

δ_{Ay} = -0.0212 m; σ_{Bx} = 1.35e5 Pa



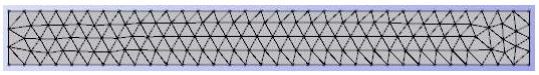
120 nodes, 87 elems

δ_{Ay} = -0.0304 m; σ_{Bx} = 2.928e5 Pa



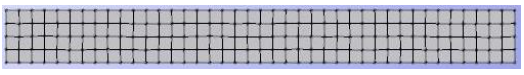
166 nodes, 258 elems

δ_{Ay} = -0.02803 m; σ_{Bx} = 2.149e5 Pa



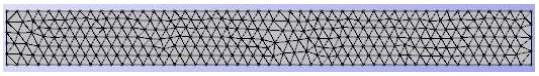
205 nodes, 160 elems

δ_{Ay} = -0.0313 m; σ_{Bx} = 2.965e5 Pa



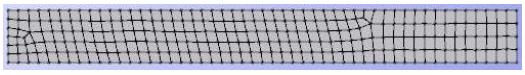
333 nodes, 554 elems

δ_{Ay} = -0.03005 m; σ_{Bx} = 2.598e5 Pa



306 nodes, 250 elems

δ_{Ay} = -0.0316 m; σ_{Bx} = 2.975e5 Pa

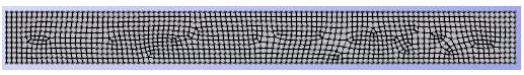


1203 nodes, 2184 elems

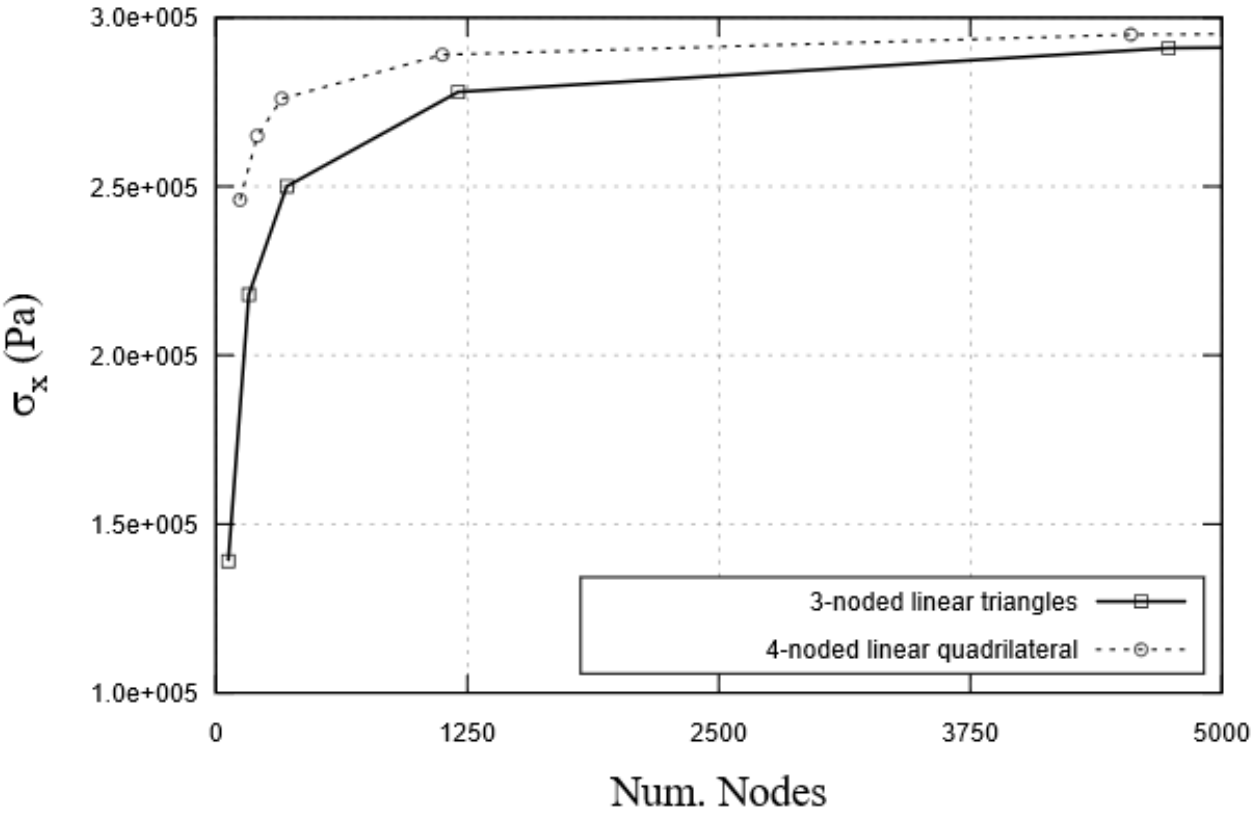
δ_{Ay} = -0.0317 m; σ_{Bx} = 2.789e5 Pa

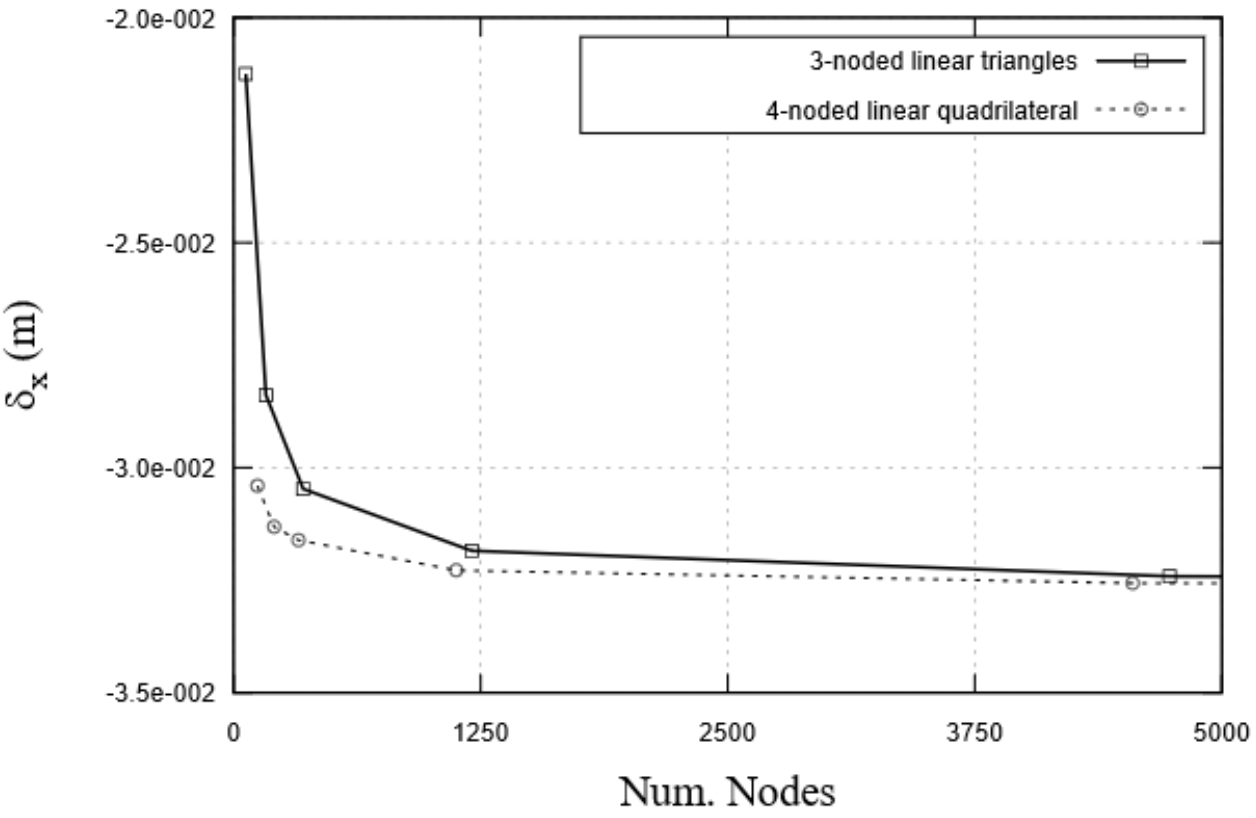
1195 nodes, 1084 elems

δ_{Ay} = -0.0322 m; σ_{Bx} = 3.037e5 Pa



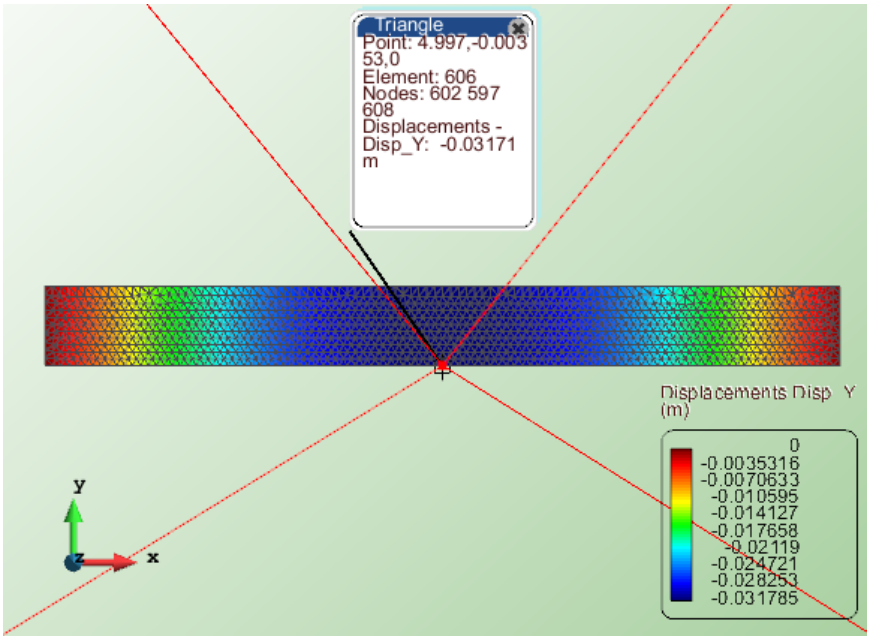
The results above are represented in the following tables:


3.0e+005
2.5e+005
2.0e+005
1.5e+005
1.0e+005
σx (Pa)
0
1250
2500
3750
5000
Num. Nodes
3-noded linear triangles
4-noded linear quadrilateral

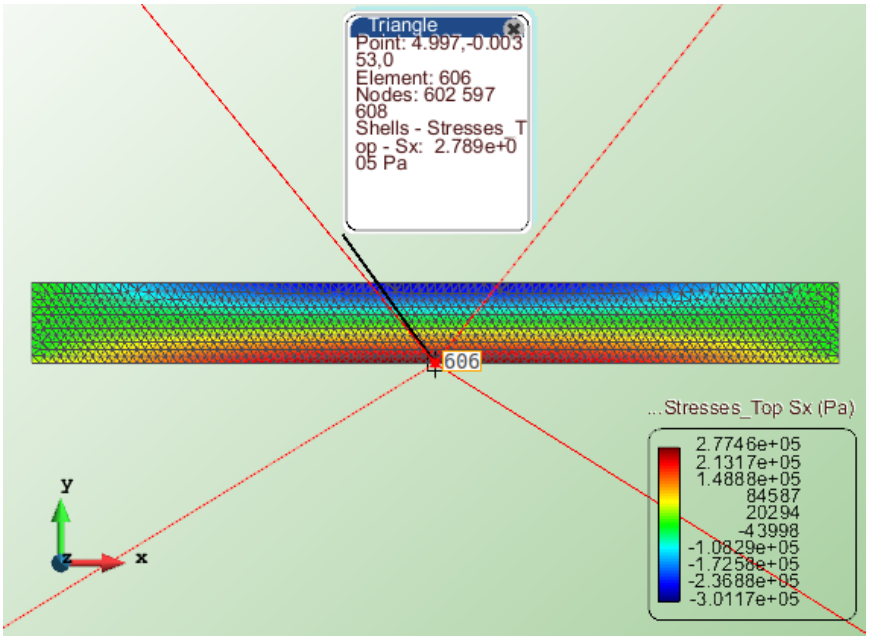

-2.0e-002
-2.5e-002
-3.0e-002
-3.5e-002
δx (m)
0
1250
2500
3750
5000
Num. Nodes
3-noded linear triangles
4-noded linear quadrilateral

The convergence results shown in the figures above are similar to those reported in [1].

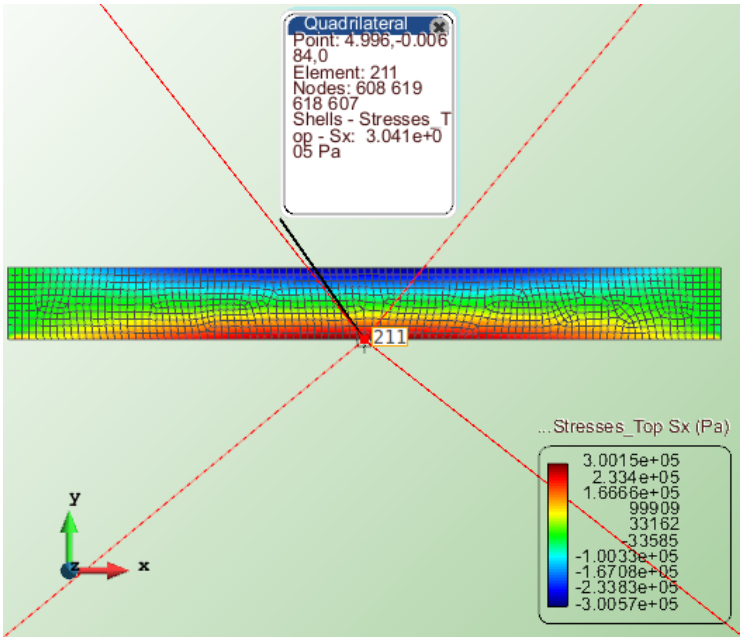
Next, contourn map results concerning the vertical deflection and the horizontal stress are shown for the finest meshes (triangles and rectangles) used in the present analysis.



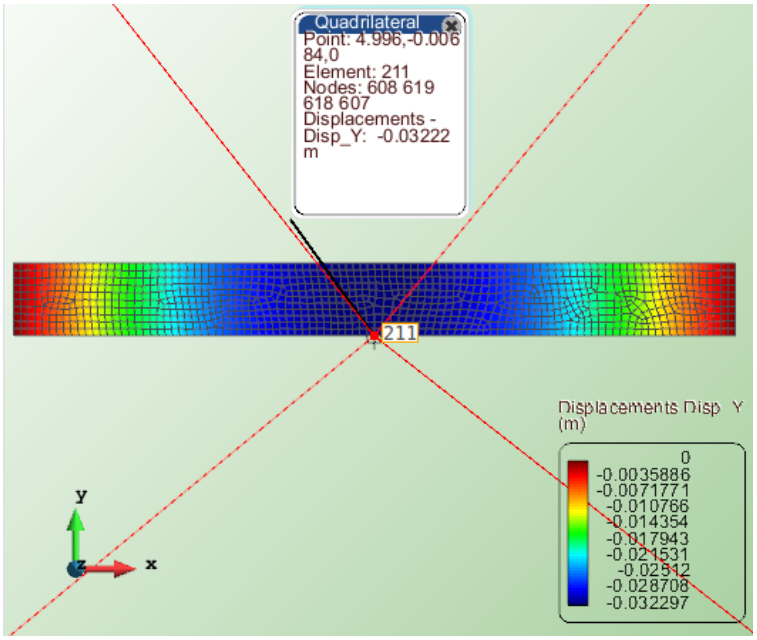
Vertical deflection at middle point (triangles, 1203 nodes mesh)



Sx stress at middle point (triangles, 1203 nodes mesh)



Vertical deflection at middle point (rectangles, 1195 nodes mesh)



Sx stress at middle point (rectangles, 1195 nodes mesh)

Reference

[1] Eugenio Oñate. Structural Analysis with the Finite Element Method. Linear Statics. Volume 1. Basis and Solids. Springer, 2009.

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