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RamSeries - Validation Case 21

Hertzian contact

RamSeries

Version
15.1.0

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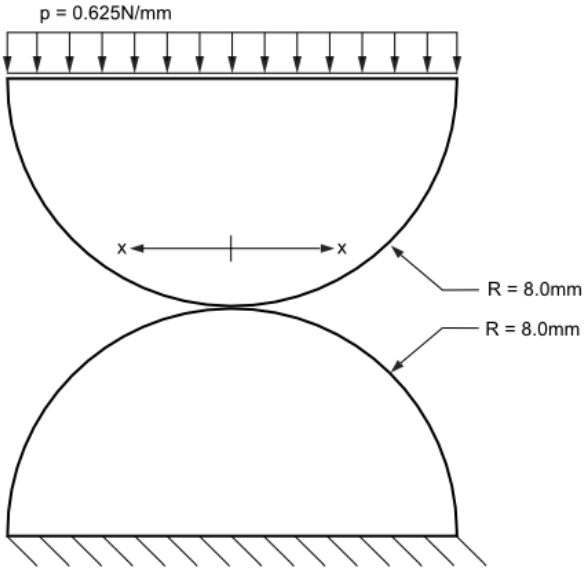
Model Description

To investigate the accuracy of contact implementation, a cylinder on cylinder Hertzian contact problem is analyzed.

Following the geometric setup and data used are shown.



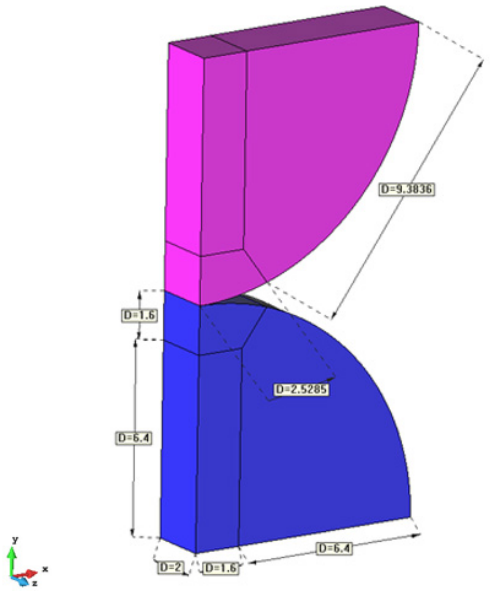
E = 200 N/mm^2 (Young's modulus)

v = 0.3 (Poisson's ratio)

p = 0.625 N/mm

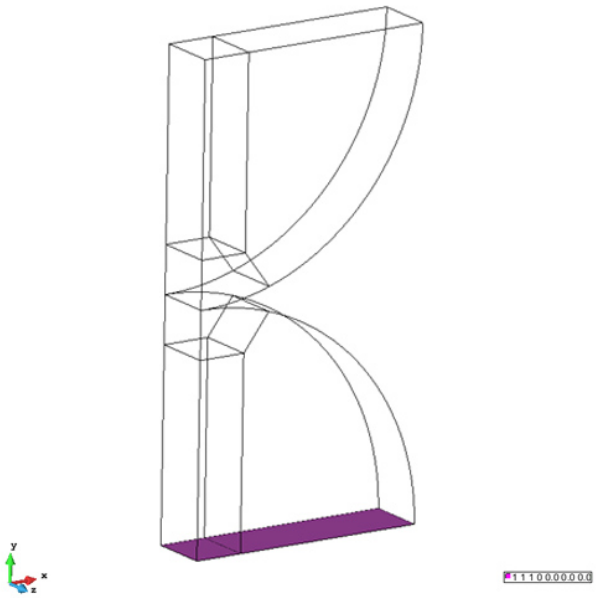
R = 8.0

Following the model used in GID:

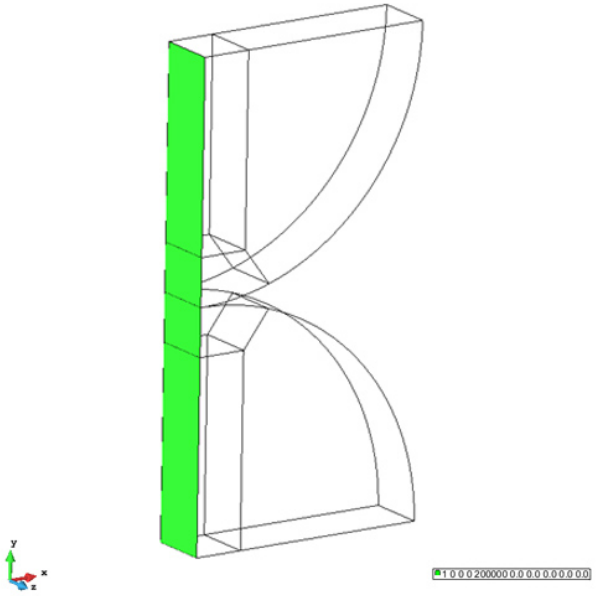


Data:

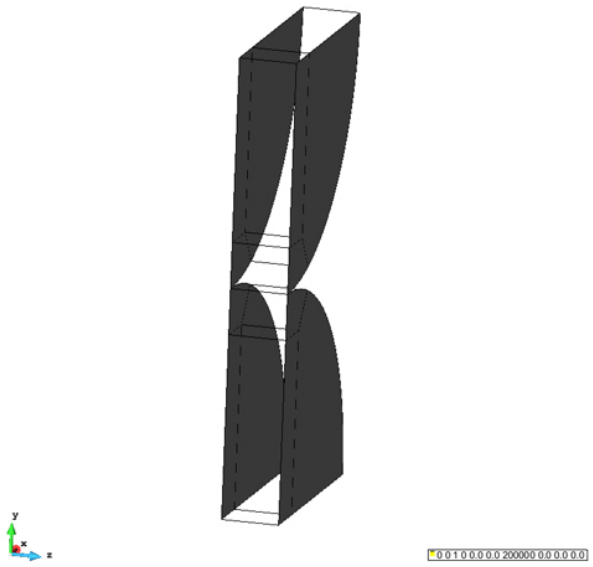
- Units:
  - Geometry units: mm
  - General units:
    - Length: mm
    - Force: N
- Analysis:
  - Analysis type: Incremental Loads Analysis
  - Material constitutive model: Plasticity on materials
  - Geometric constitutive model: Linear geometry
  - Boundary conditions: Linear boundary conds.
- Non-Linear analysis data:
  - Solver control: Load control
  - Conv. tolerance: 1e-4
  - Iteration type: Full Newton-Raphson
  - Mas iterationts: 40
- Incremental analysis data:
  - Num. increments: 10
- Fixed constraints:
  - X, Y, Z: 1



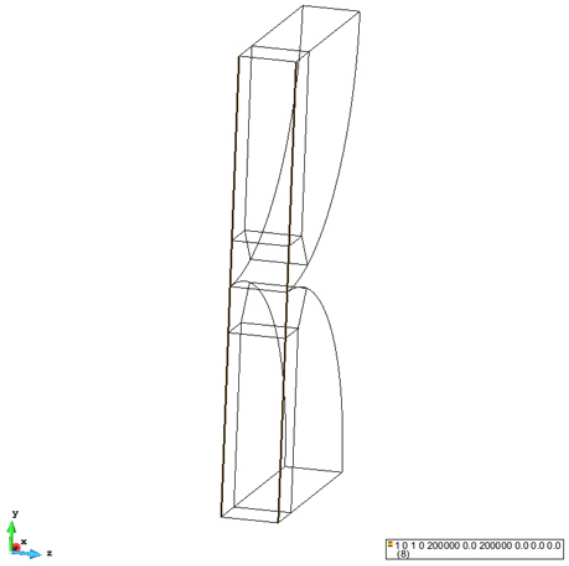
- Elastic constraints:
  - X : 1 X stiffness: 2e6 [N/mm^3]
  - Y, Z: 0



- Elastic constraints:
  - X, Y: 0
  - Z: 1 Z stiffness: 2e6 [N/mm^3]

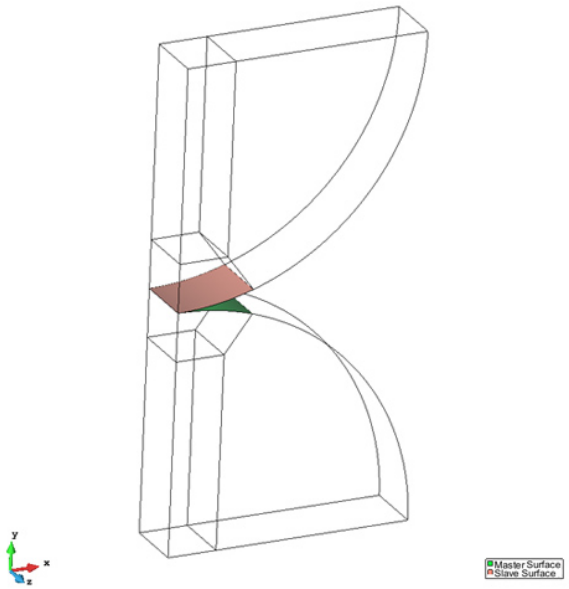


- Elastic constraints:
  - X, Z : 1 X, Z stiffness: 2e6 [N/mm^3]
  - Y: 0

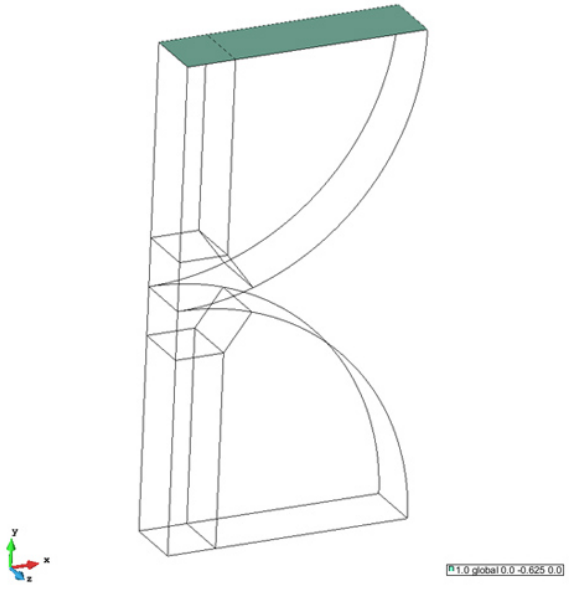


Master-Slave contacts Surf-Surf

- Contact type: Frictionless



- Pressure Load:
  - X, Z : 0 [N/mm^2]
  - Y: - 0.625 [N/mm^2]



Results

Analytical solution

According to Reference [1], the width b, being the half or the contact zone, can be calculated analytically with

$$b=2\sqrt{PR\frac{1-\nu^2}{\pi E}}=0.6808\ [\text{mm}],$$

the normal pressure distribution in the contact zone is given with

$$\sigma=\sigma_{max}\sqrt{1-\left(\frac{x}{b}\right)^2},$$

where σ_{max} is the maximum normal pressure computed via

$$\sigma_{max}=\sqrt{\frac{PE}{\pi(1-\nu^2)R}}=9.351\ \left[\frac{N}{mm^2}\right]$$

where:

P = 0.625 [N/mm]

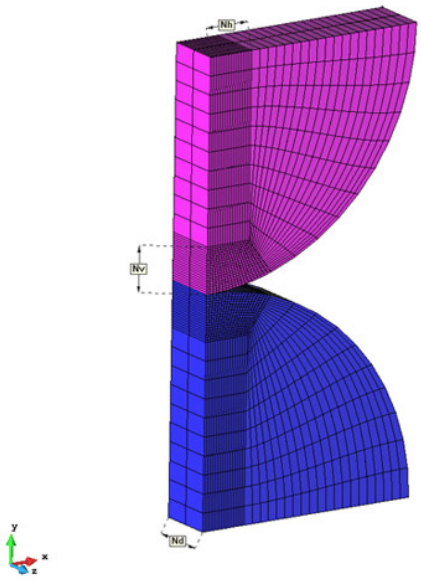
R = 8 [mm]

v = 0.3

E = 200 [N/mm^2]

Mesh

The model has been meshed with hexahedra elements defining the number of cells for each line:



Nd: 2 (number of cells)

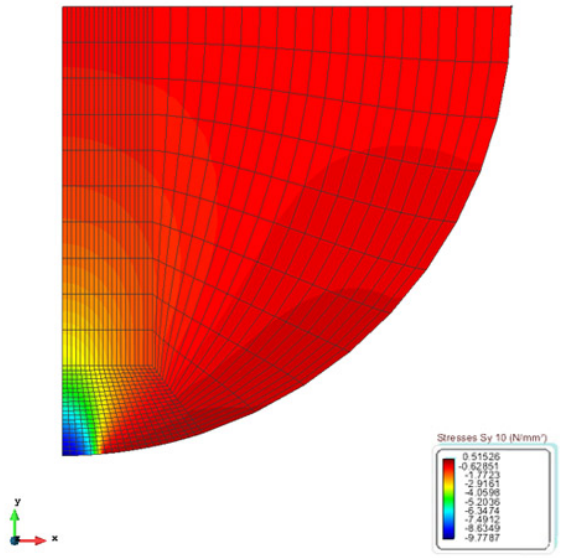
Nh: 20, 30, 40, 50, 60 (number of cells)

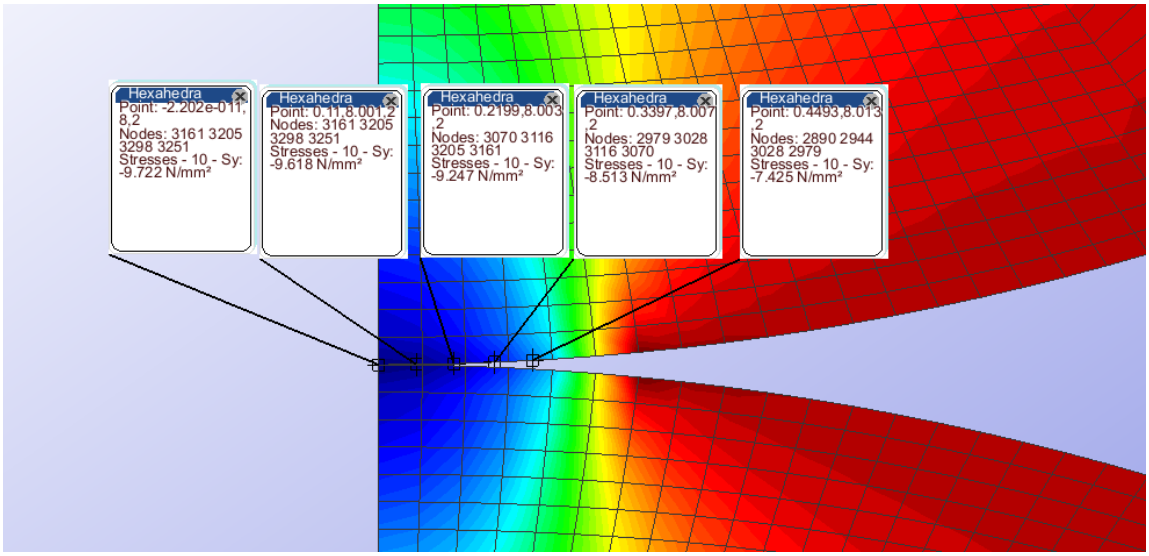
Nv: 20, 30, 40, 50, 60 (number of cells)

Number of cells of other lines: 10

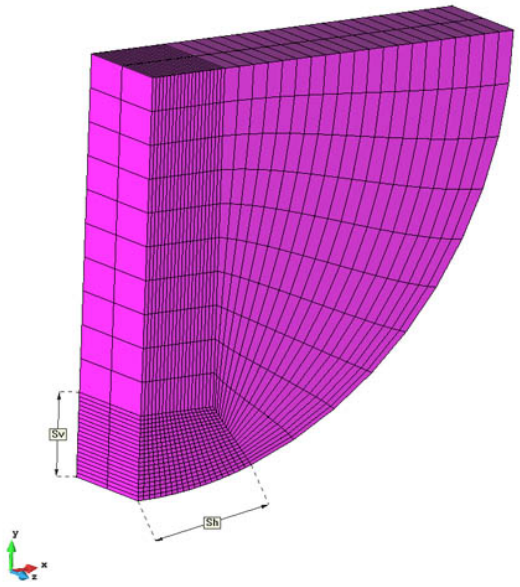
Numerical results

Following the stresses in the top hemicylinder are shown and analyzed:





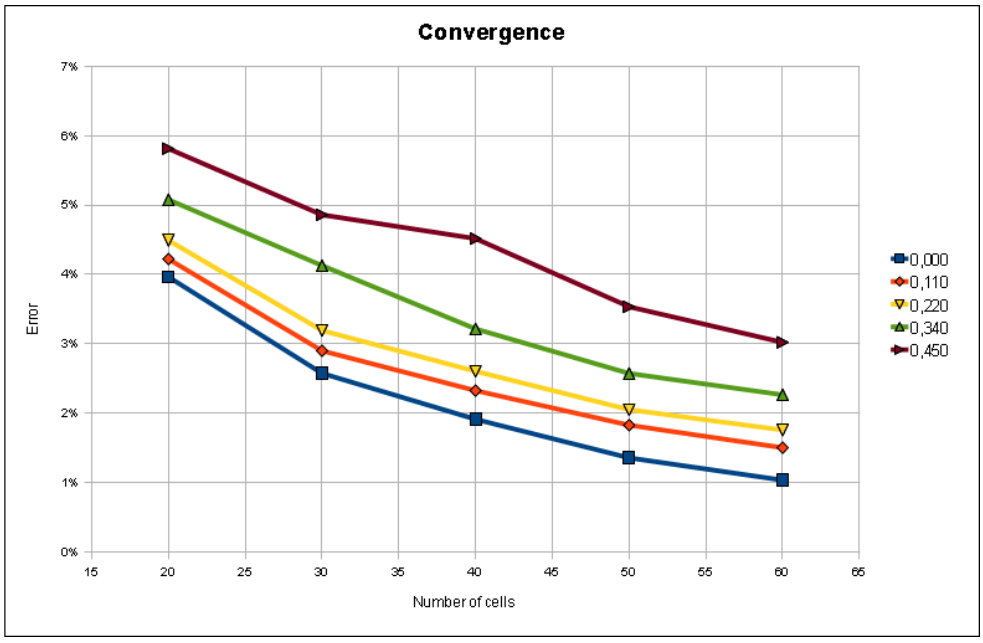
Different number of cells has been used to check convergence of the results.



Following different results according different number of cells are shown.

Mesh	1	2	3	4	5
Sh [mm]	0.13	0.08	0.06	0.05	0.04
Sv [mm]	0.08	0.05	0.04	0.03	0.03
Num. nodes	5107	9427	14947	21667	29587
Nh	20	30	40	50	60
Nv	20	30	40	50	60

	Mesh	1	1	2	2	3	3	4	4	5	5
X [mm]	Analytical Result [N/mm2]	Numerical Result [N/mm2]	Error [%]	Numerical Result [N/mm2]	Error [%]	Numerical Result [N/mm2]	Error [%]	Numerical Result [N/mm2]	Error [%]	Numerical Result[N/mm2]	Error [%]
0.00	9.35	9.72	4.0	9.59	2.8	9.53	1.9	9.48	1.4	9.45	1.0
0.11	9.23	9.62	4.2	9.50	2.9	9.44	2.3	9.40	1.8	9.37	1.5
0.22	8.85	9.25	4.5	9.13	3.2	9.08	2.6	9.03	2.0	9.01	1.8
0.34	8.10	8.51	5.1	8.44	4.1	8.36	3.2	8.31	2.6	8.29	2.3
0.45	7.02	7.43	5.8	7.36	4.9	7.33	4.5	7.27	3.5	7.23	3.0
Max error			5.8		4.9		4.5		3.5		3.0



References

[1] S. Hartmann, J. Oliver, R Weyler, J.C. Cante, J.A. Hernández. A contact domain method for large deformation frictional contact problems. Part 2: Numerical aspects.

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