POLITECNICO DI MILANO

Finite Element Simulation For Mechanical Design

Simple contact analysis

Prof. Andrea Bernasconi
Dr. Luca M. Martulli

3D – Cube on cube

Cube 10x10 mm

Pressure 10 MPa

Prevent rigid motions!

cube-on-cube.cae

cube-on-cube.jnl

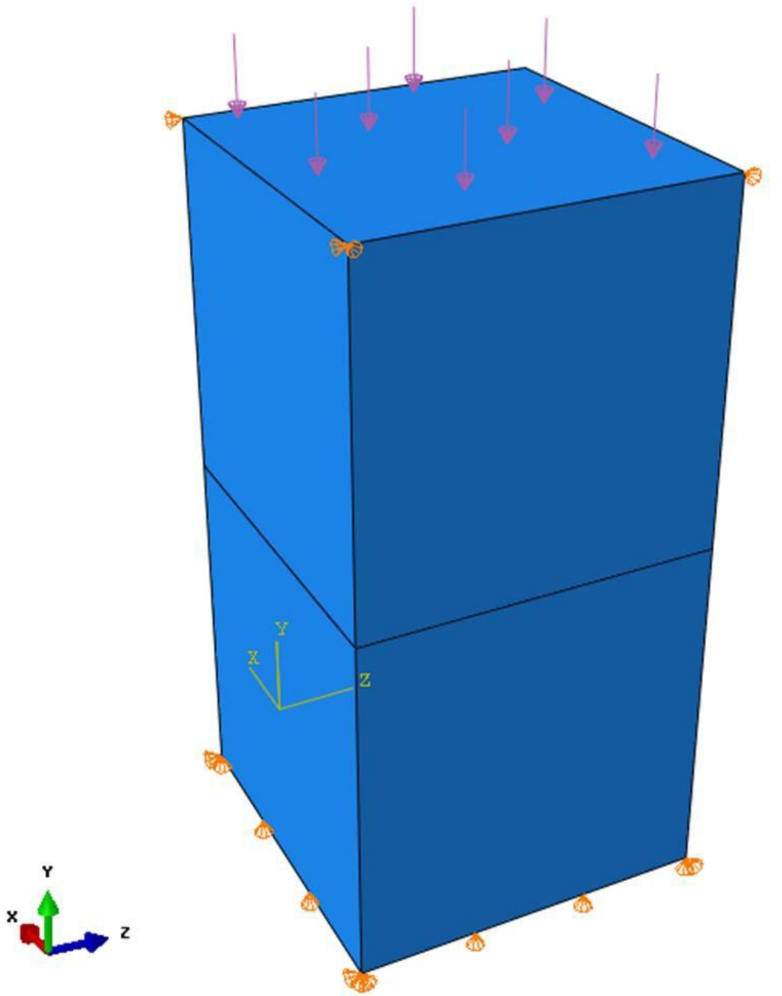
C3D8R_LM_N-to-S_SS

C3D8R_LM_S-to-S_SS

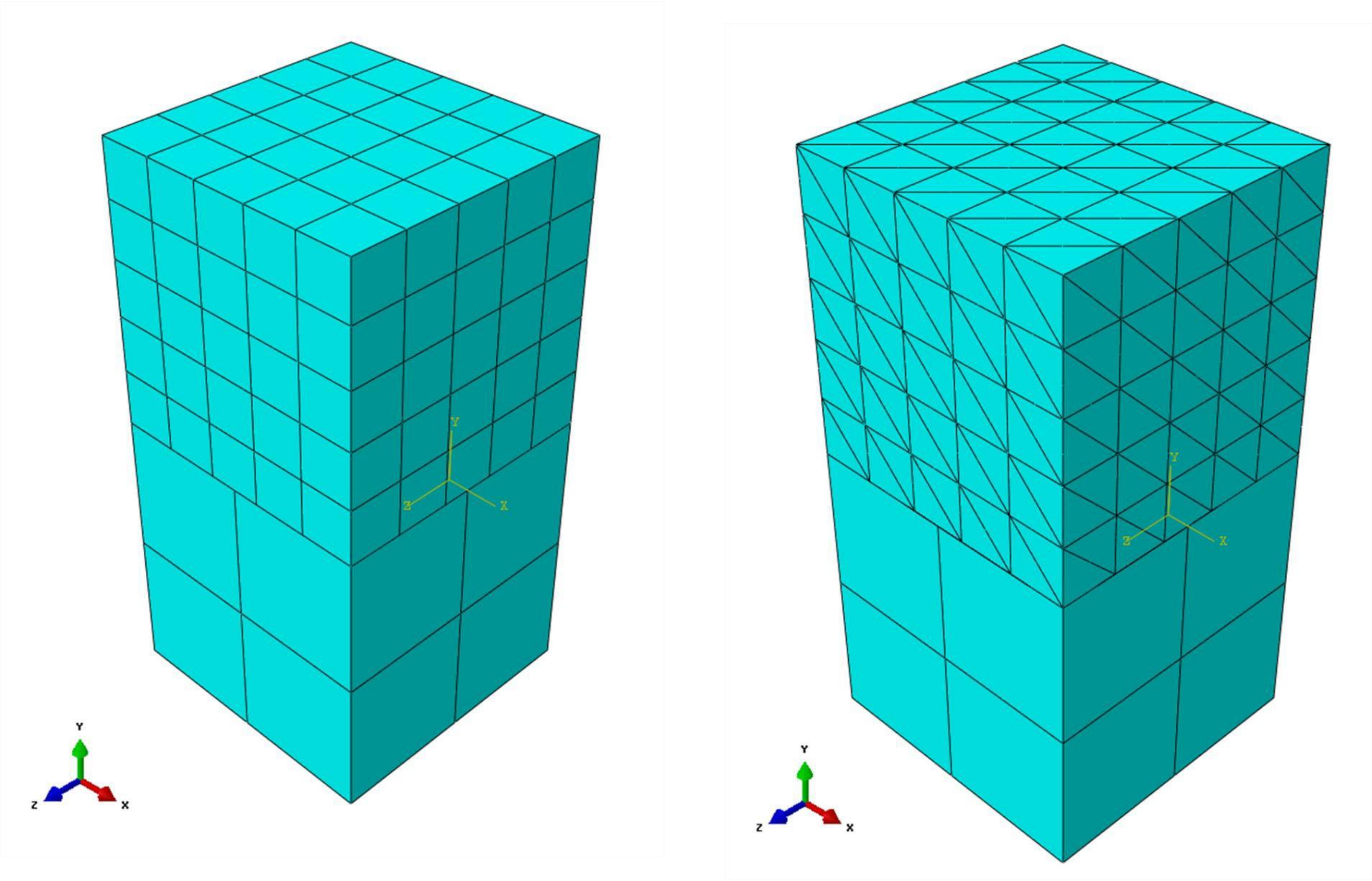
C3D8R_PM_N-to-S_SS

C3D10_PM_N-to-S_SS

C3D10_PM_S-to-S_SS



3D – Cube on cube



Contact discretization techniques

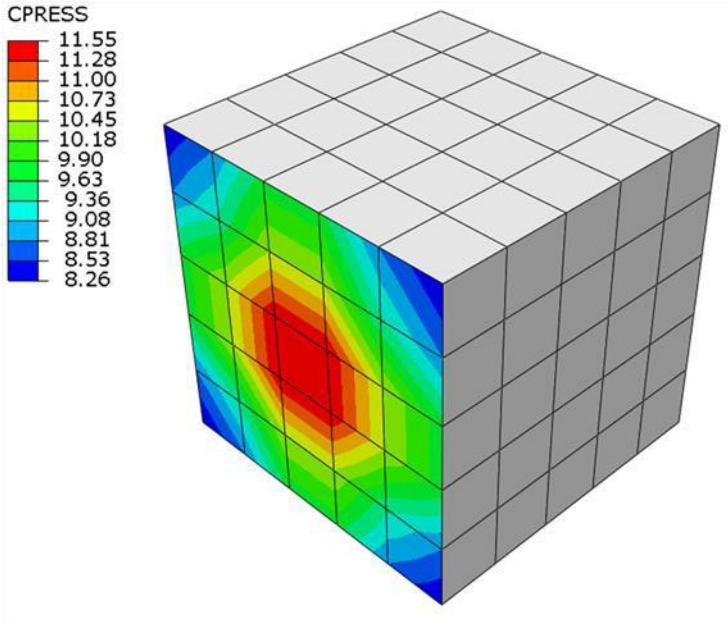
Node-to-Surface

Element type:

C3D8R

Contact Enforcement:

Lagrange Multiplier



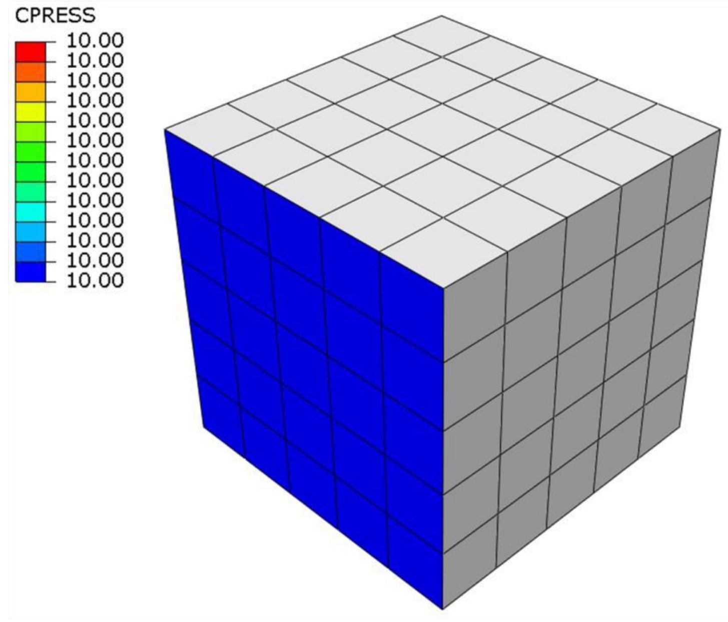
Surface-to-Surface

Element type:

C3D8R

Contact Enforcement:

Lagrange Multiplier



Contact enforcement methods

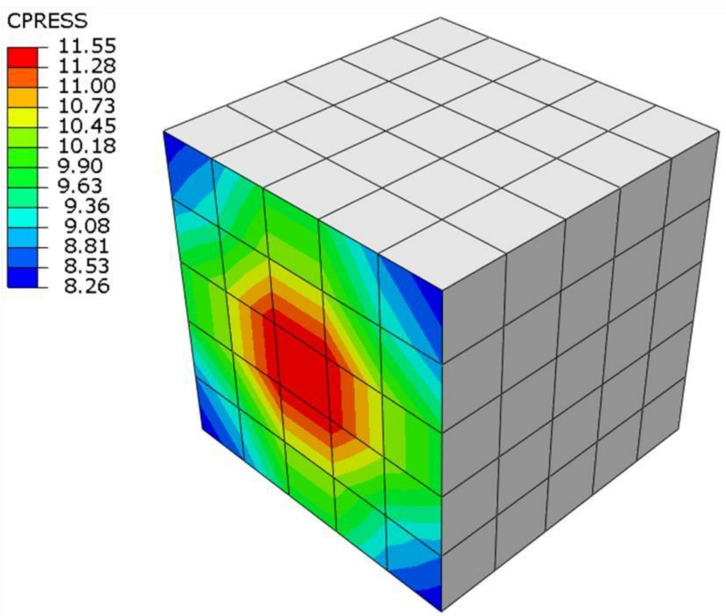
Lagrange Multiplier Method

Element type:

C3D8R

Contact Discretization:

Node-to-Surface



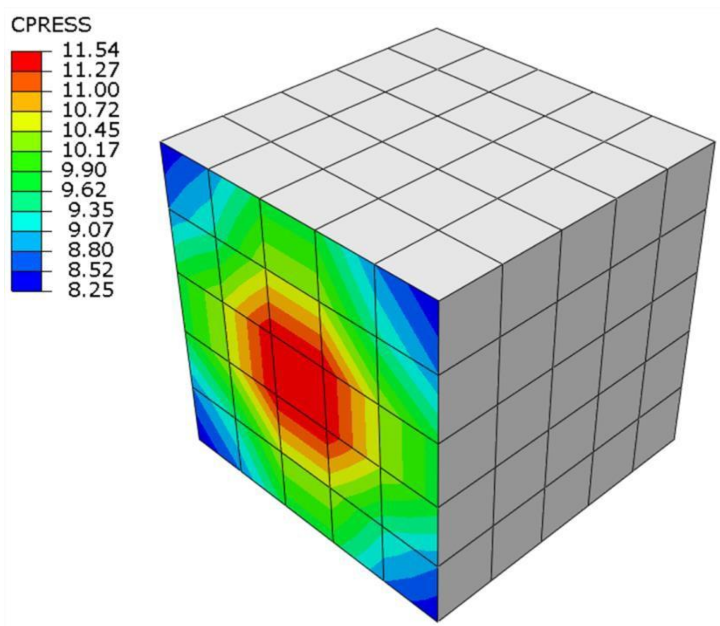
Penalty Method

Element type:

C3D8R

Contact Discretization:

Node-to-Surface



Contact enforcement methods

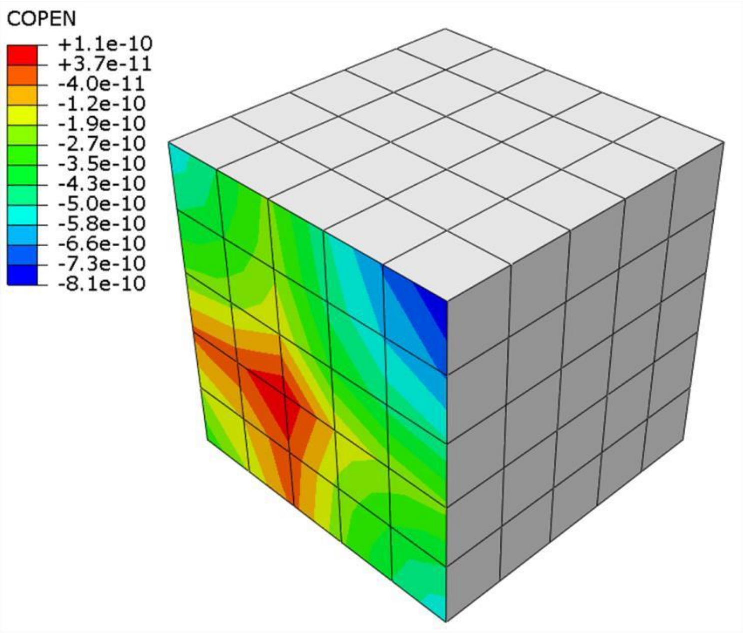
Lagrange Multiplier Method

Element type:

C3D8R

Contact Discretization:

Node-to-Surface



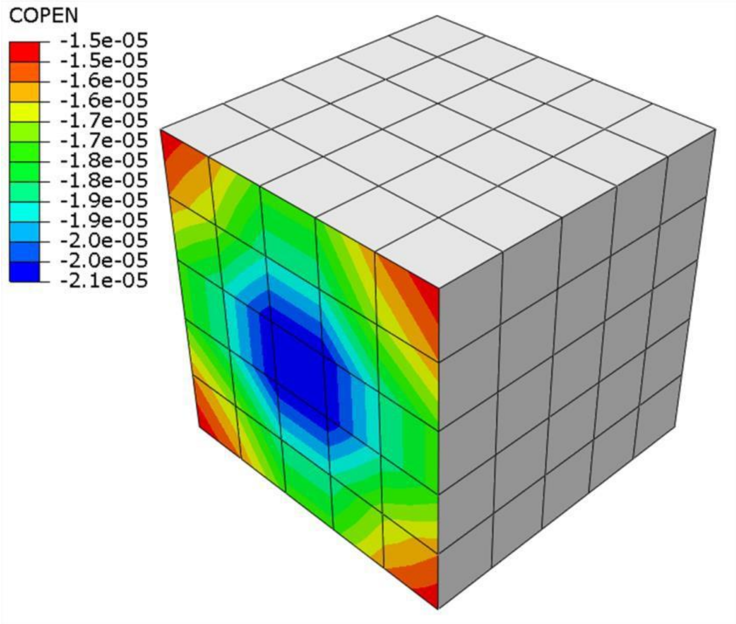
Penalty Method

Element type:

C3D8R

Contact Discretization:

Node-to-Surface



POLITECNICO DI MILANO

Finite Element Simulation For Mechanical Design

Contact between two objects

Prof. Andrea Bernasconi
Dr. Luca M. Martulli

2D – Disc on block

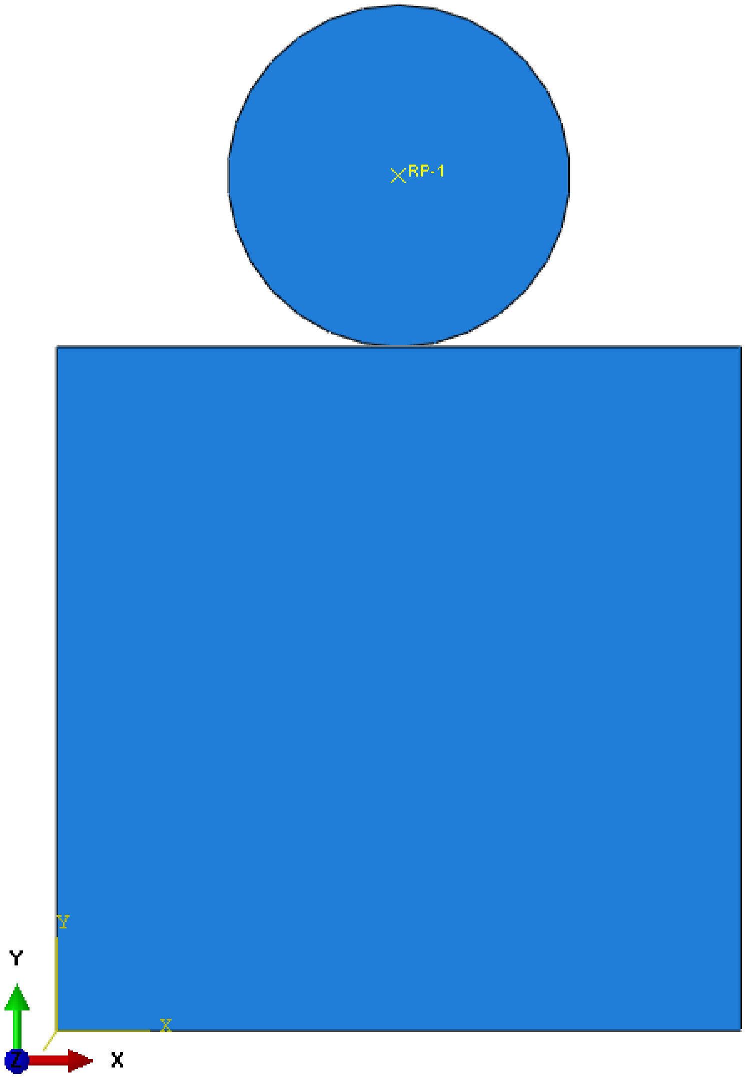
Problem statement

A steel cylinder is pressed into an aluminum block.

Consider a linear elastic behaviour for both materials, and they are homogeneous.

A vertical (y-direction) point load of F=35kN/mm is applied to the cylinder.

A 2D approximation (plane strain) is assumed to be satisfactory.



2D – Disc on block

Problem statement

Geometry

Block height = 200 mm

Block width = 200 mm

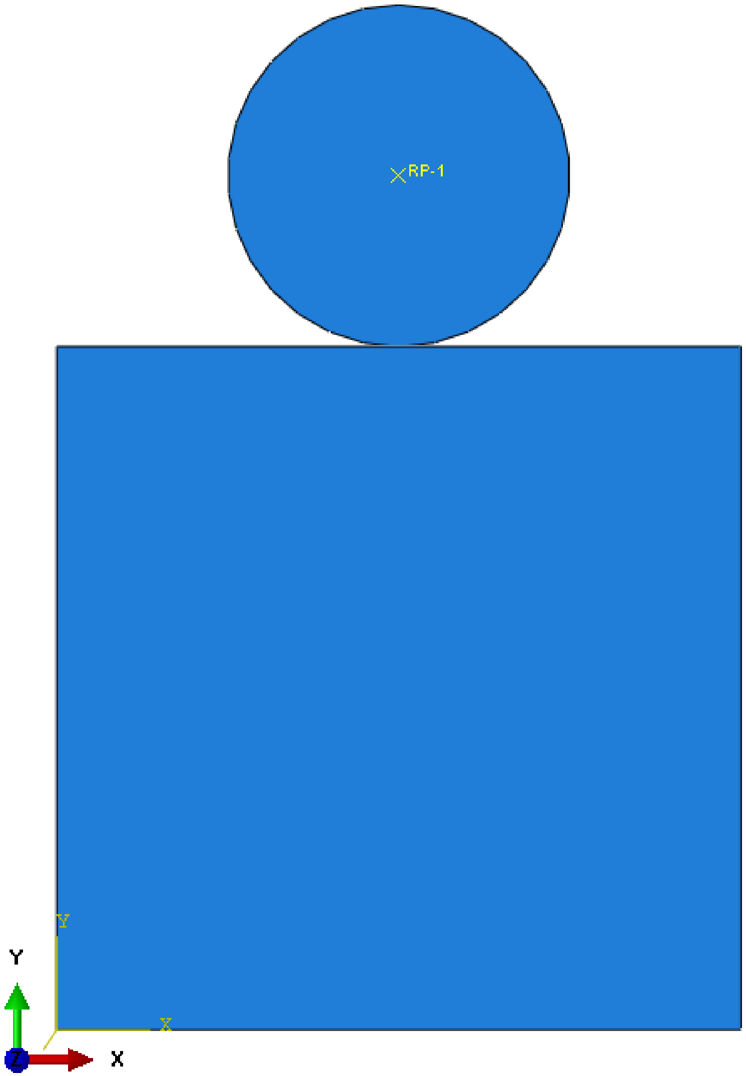
Cylinder diameter = 100 mm

Material properties

E_cyl = 210 Gpa

E_block = 70 Gpa

nu_cyl = nu_block = 0.33



2D – Disc on block

Analytical solution

Maximum pressure

$$p_H = \sqrt{\frac{w}{\pi}\frac{E'_{12}}{\rho_{12}}} = 3585\ N/mm^2$$

Semi-width of contact area

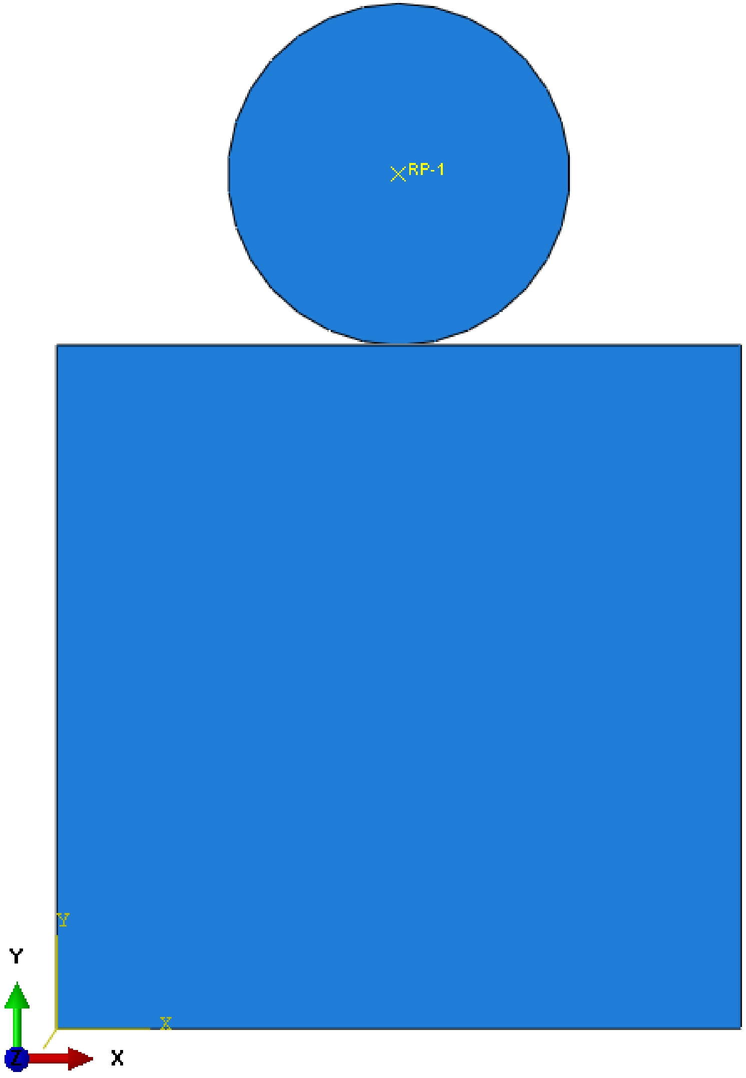
$$b_H = 2\sqrt{\frac{w}{\pi}\frac{\rho_{12}}{E'_{12}}} = 6{,}215\ mm;$$

where

Equivalent radius of curvature

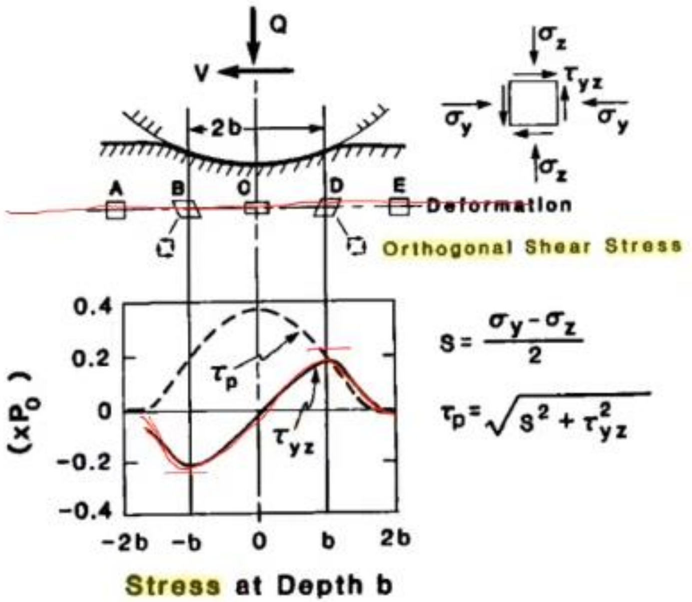
Equivalent elastic modulus

Elastic modulus



2D – Disc on block

Shear stresses without friction



$$\max_{(\overline{x},\overline{y})}\left\{\overline{\tau}_{H}\right\} = 0.300 \text{ at } \overline{x} = 0.00, \overline{y} = 0.78$$

$$\max_{(\overline{x},\overline{y})}\left\{\overline{\tau}_{os}\right\} = 0.256 \text{ at } \overline{x} = 0.85, \overline{y} = 0.50$$

Guidelines for choosing master/slave

When a contact pair contains two surfaces, the two surfaces are not allowed to include any of the same nodes and you must choose which surface will be the slave and which will be the master.

For simple contact pairs consisting of two deformable surfaces, the following basic guidelines can be used:

- The larger of the two surfaces should act as the master surface.
- If the surfaces are of comparable size, the surface on the stiffer body should act as the master surface.
- If the surfaces are of comparable size and stiffness, the surface with the coarser mesh should act as the master surface.