Verification of Truss Element Type

This documentation provides an analytical calculation of the axial deformation and stress in a one-dimensional truss element. The calculation is based on Hooke's law and fundamental static principles.

1. Formulas

1. Axial Deformation:

The axial deformation of a truss element is described by Hooke's law:

$$u = \frac{F \cdot L}{A \cdot E} \tag{1}$$

Where:

F: Axial force in Newton [N]

L: Length of the truss element in meters [m]

A: Cross-sectional area in square meters [m²]

E: Modulus of elasticity in Pascal [Pa]

u: Change in length in meters [m]

2. Stress:

The stress sigma in the truss element is given by:

$$\sigma = \frac{F}{A} \tag{2}$$

2. Example Calculation

Given the following parameters:

- Length of the truss element, L = 2 [m]
- Cross-sectional area, A = 0.01 [m²]
- Modulus of elasticity, E = 2.0E+05 [Pa]
- Axial force, F = 1000 [N]

1. Axial Deformation:

Inserting into (1) leads to an axial deformation of

$$u = \frac{F \cdot L}{A \cdot E} = \frac{1000 \cdot 2}{0.01 \cdot 2.0E05} = 1\ [m].$$

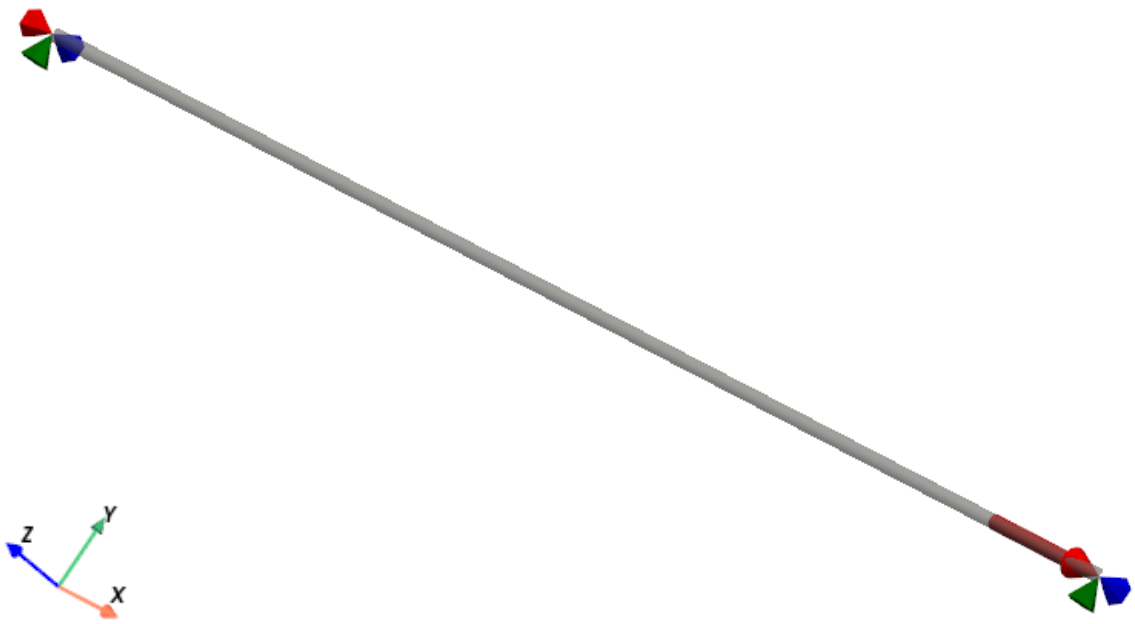
3. Stress:

Inserting into (2) leads to a stress of

$$\sigma = \frac{F}{A} = \frac{1000}{0.01} = 1.0E05\ \left[\frac{N}{m^2}\right].$$

3. FE-Model

The FE-Structure is provided in “Verify_Element_Truss.py”. The structure consists of a single linear truss element. The first node is fully constrained and the second node is constrained in y- and z-direction. The force is applied to the second node in x direction.



Solving the structure using the direct stiffness algorithm leads to a displacement of 1 [m] as well as of a stress of 1.0E05 [N/m²] which is in accordance with the analytical solution. The results can be printed to a text file using the “print_info()” method of the “Structure.py” object, a snippet is shown below.

```
Listing information of nodes and elements
Nodes:
   Node_ID 0:
      Coordinates: (0.000 0.000 0.000)
      Displacement: (0.000e+00 0.000e+00 0.000e+00)
      Constraints: (False, False, False)
      Force: (0, 0, 0)
   Node_ID 1:
      Coordinates: (2.000 0.000 0.000)
      Displacement: (1.000e+00 0.000e+00 0.000e+00)
      Constraints: (True, False, False)
      Force: (1000, 0, 0)

Elements:
   Element_ID 0:
      Node_ID's: (0, 1)
      Von-Mises stress: 100000.0
```