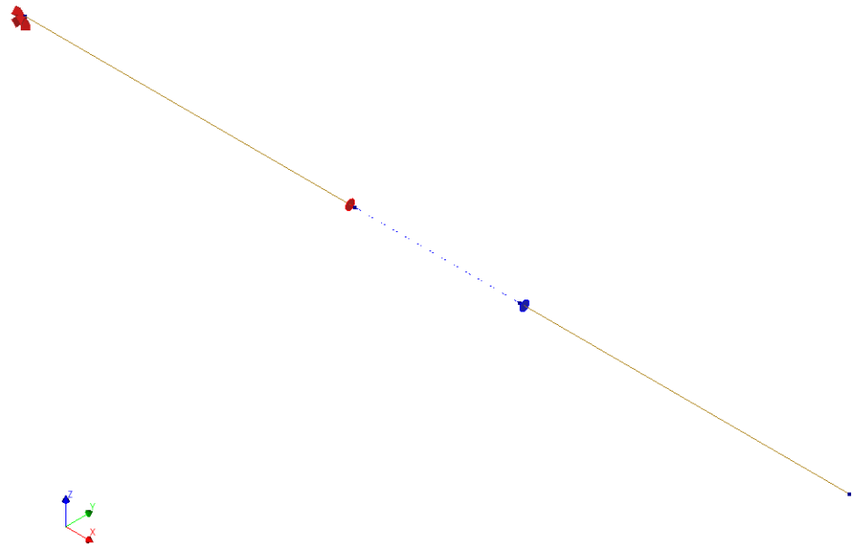
Tutorial

Spring elements in Diana



DIANA FEA

Outline

1 Introduction

This tutorials describes how to define different types of springs available in DianaIE[1].
There are three classes of spring elements in DianaIE:

- discrete spring/dashpots
  to model the interaction between two points of the finite element model or between one point and the *world* (boundary springs)
- matrix spring elements
  to model coupling between the three translational and three rotational degrees of freedom in a node
- base spring elements
  to model behavior at the base of frames

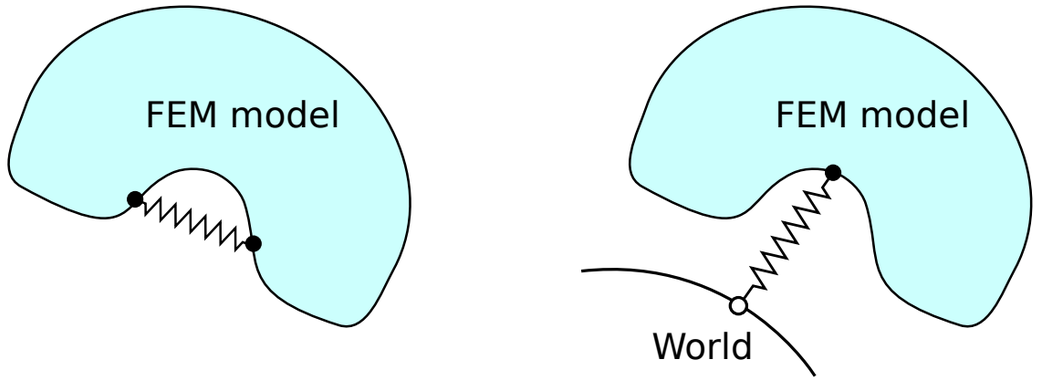


Figure 1: Discrete springs

[1] The common steps of creating a model are not explained in detail.

2 Finite Element Model

We create a beam element model to exemplify the different types of springs as connections. In order to create a finite element mesh we need to define the material and geometrical properties and supports of the beam.

We first define the beam model with the following characteristics:

- the beam has 1 m length
- for material model we use the default model in DIANAIE from model code MC2010
- for geometry definition we consider a circular cross-section with 0.2 m of diameter
- the element type is Class III 3D beam
- the beam is clamped at one side and free at the other side
- the mesh is generated with the default mesh properties of DIANAIE

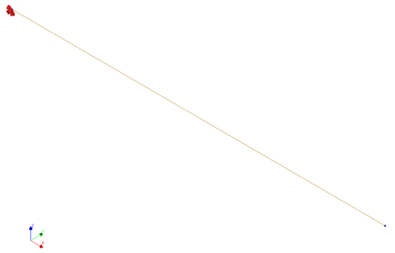


Figure 2: Model with one beam

We define the different types of springs in the free edge of the beam:

- one-node discrete spring (boundary spring) [Fig. 2] [Section 3]:
  translational [Section 3.1]
  rotational [Section 3.2]
  nodal (matrix spring) [Section 3.3]
- open two-node discrete spring [Fig. 3] [Section 4]:
  translational [Section 4.1]
  rotational [Section 4.2]
  base spring [Section 4.3]
- close two-node discrete spring (connecting coincident vertices) [Section 5]

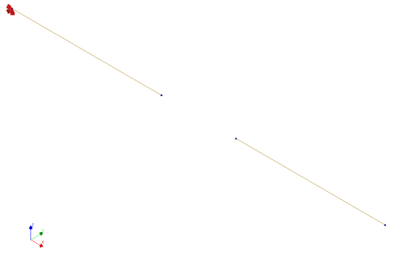


Figure 3: Model with two beams

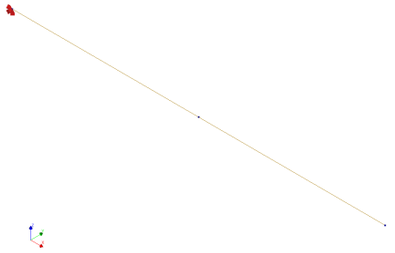


Figure 4: Model with two beams with coincident vertices

3 Boundary Spring Elements

Boundary springs are use to make one-node discrete connection between one point in the model and the *world* [Fig. 1b]. In the following the different types of boundary springs are presented.

3.1 Translational Boundary Spring

We define a connection at the free end of the beam to create a boundary spring with a discrete translation spring/dashpot element. In the material properties the translational stiffness is defined and the damping is optional[2].

DIANAIE

Main menu → Geometry → Assign → Connections [Fig. 5]
Edit connections → Material → Add material [Fig. 6] → Edit material [Fig. 7]

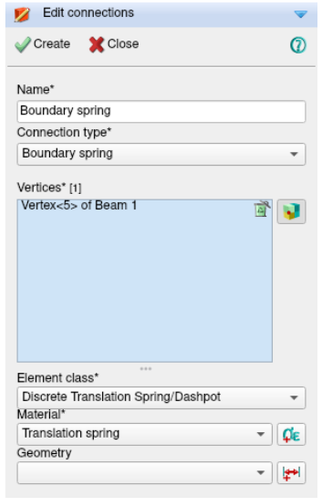


Figure 5: Boundary spring connection

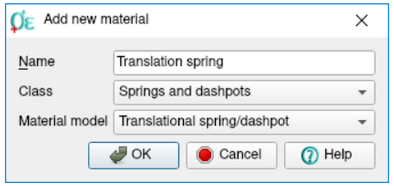


Figure 6: Add new material - translation spring

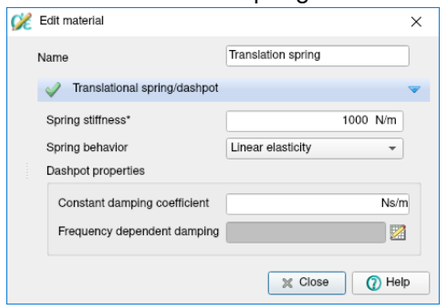


Figure 7: Edit material - translation spring

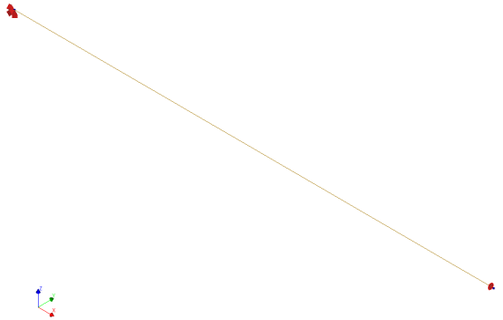


Figure 8: Geometry view

[2]The values of the spring stiffness are only illustrative and should not to be considered as a reference.

After defining the spring connection we generate the mesh. In the element types of the mesh browser in DIANAIE we can see the spring type SP1TR which is a one-node translation spring/dashpot element defined in one vertice (free end of the beam) [Fig. 11]. Element L12BEA is the Class III 3D beam elements used to model the beam.

DIANAIE

Main menu → Geometry → Mesh → Generate mesh [Fig. 9] [Fig. 10]

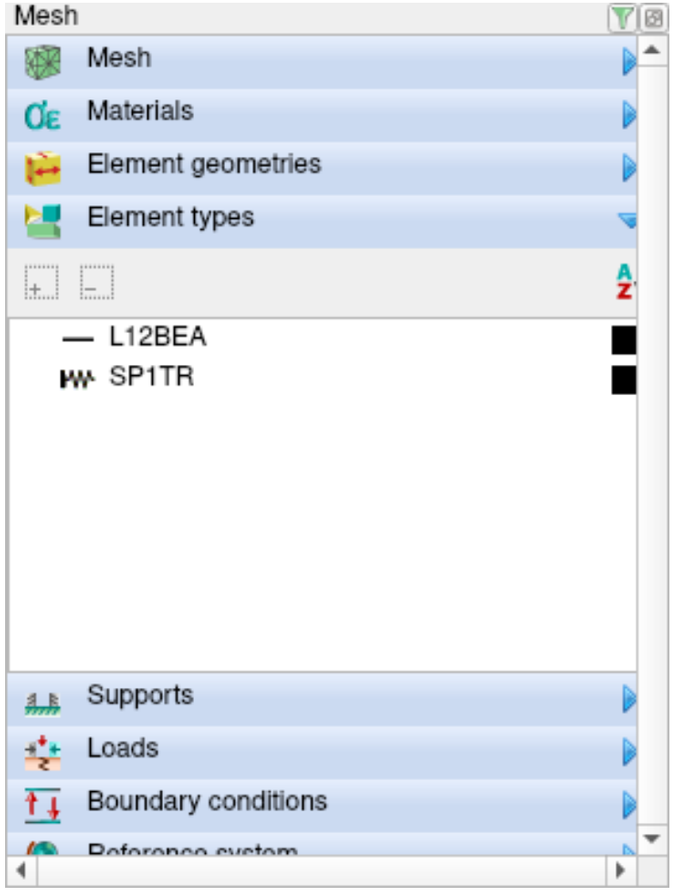


Figure 9: Mesh browser - element types

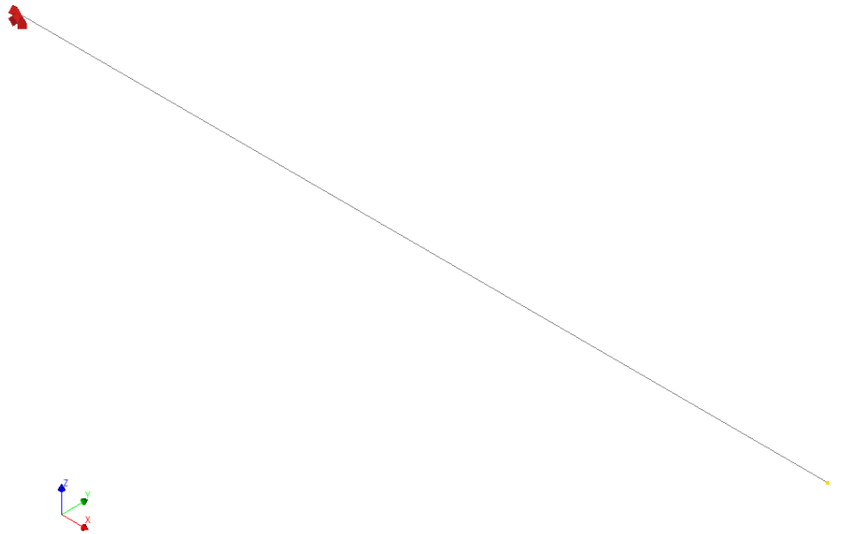


Figure 10: Finite element mesh

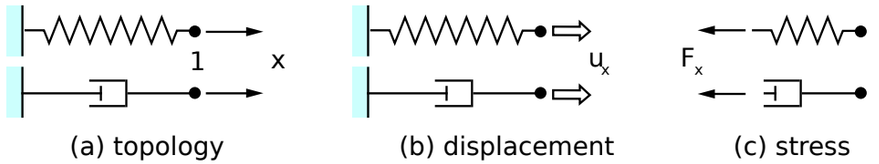


Figure 11: Spring element SP1TR

3.2 Rotational Boundary Spring

We now define the boundary spring with a discrete rotation spring/dashpot element. In the material properties the rotational stiffness is defined and the damping is optional[3].

DianaIE

Main menu → Geometry → Assign → Connections [Fig. 12]
Edit connections → Material → Add material [Fig. 13] → Edit material [Fig. 14]

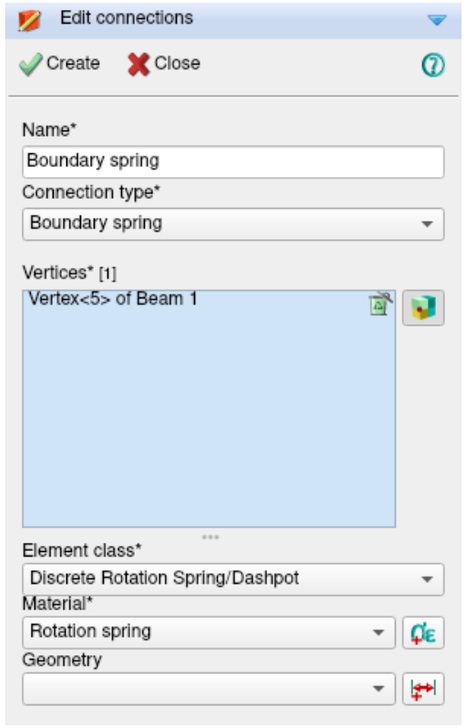


Figure 12: Boundary spring connection

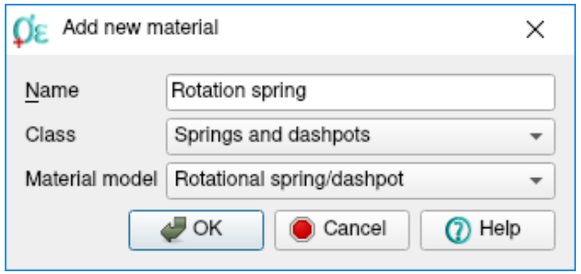


Figure 13: Add new material - rotation spring

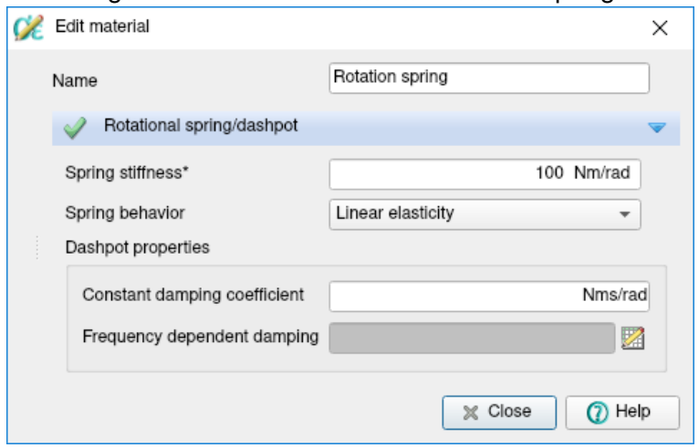


Figure 14: Edit material - rotation spring

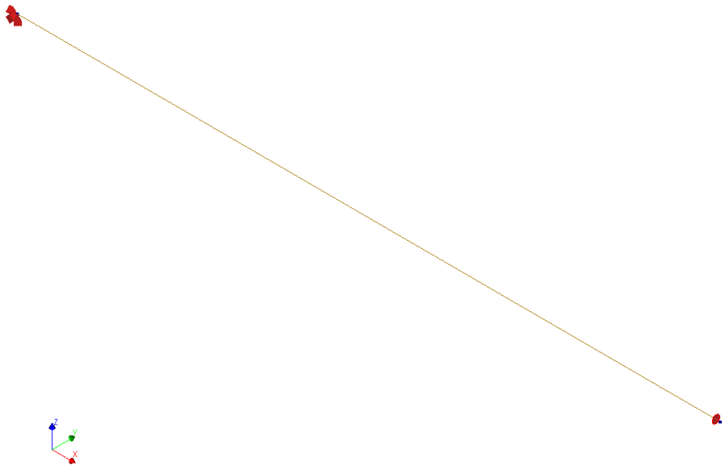


Figure 15: Geometry view

[3]The values of the spring stiffness are only illustrative and should not to be considered as a reference.

We generate the mesh. In the element types of the mesh browser in DIANAIE we can see the spring type SP1RO which is a one-node rotation spring/dashpot element defined in one vertice (free end of the beam) [Fig. 18].

DIANAIE

Main menu → Geometry → Mesh → Generate mesh [Fig. 16] [Fig. 17]

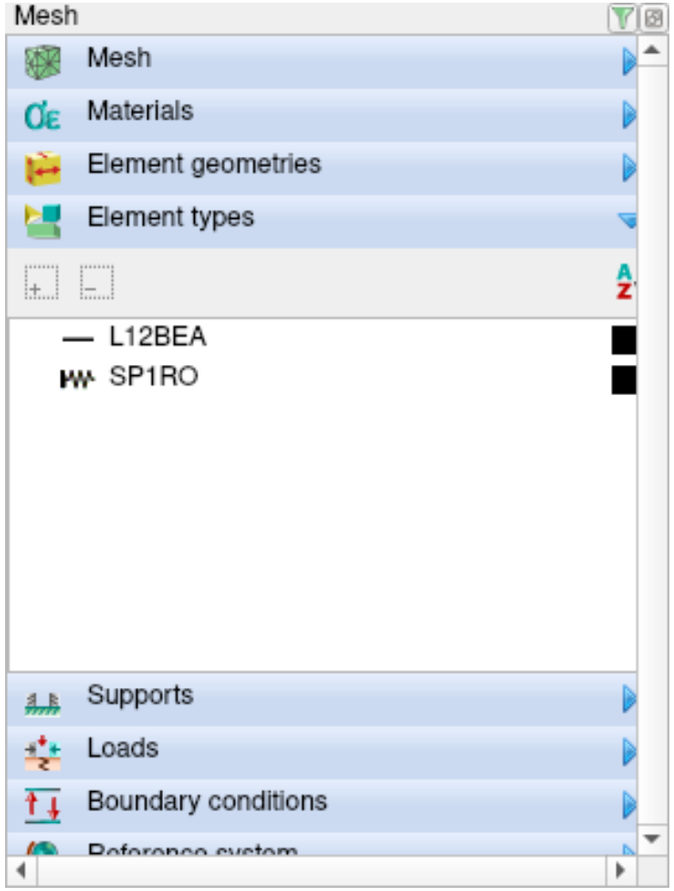


Figure 16: Mesh browser - element types

Figure 17: Finite element mesh

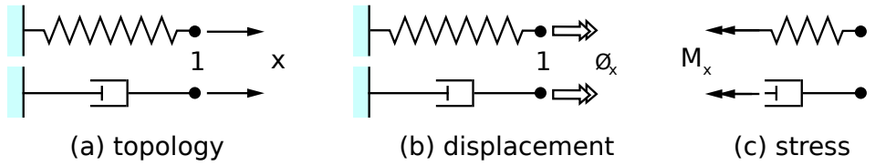


Figure 18: Spring element SP1RO

3.3 Nodal Boundary Spring

We now define the boundary spring with a nodal (matrix) spring element. In the material properties we define the nodal spring without cross-terms[4].

DianaIE

Main menu → Geometry → Assign → Connections [Fig. 19]
Edit connections → Material → Add material [Fig. 20] → Edit material [Fig. 21]

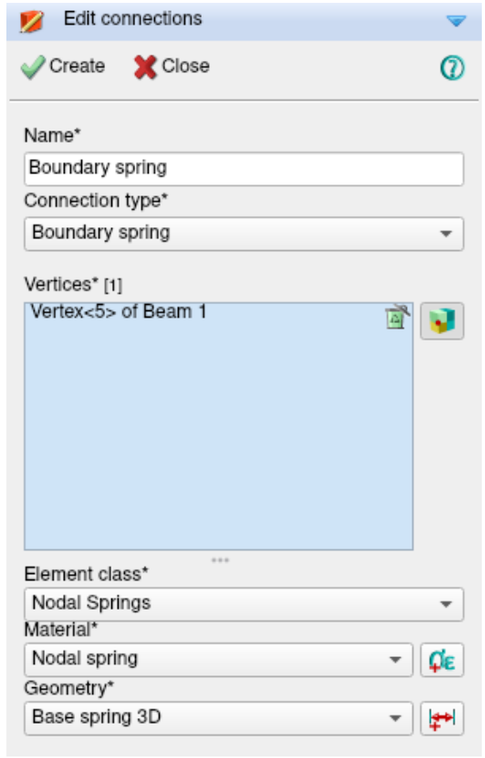


Figure 19: Boundary spring connection

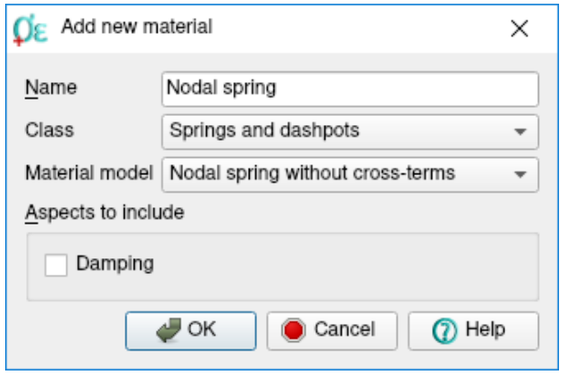


Figure 20: Add new material - nodal spring

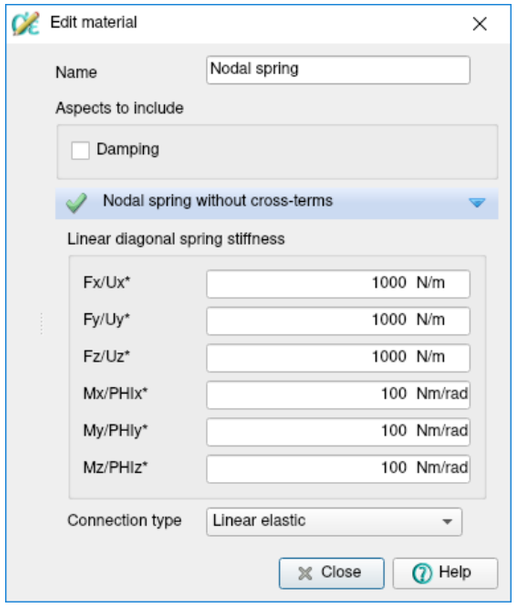


Figure 21: Edit material - spring

[4]The values of the spring stiffness are only illustrative and should not to be considered as a reference.

We define the geometry of the matrix spring by providing the direction of the local axes.

Connections → Geometry → Add new geometry [Fig. 23] [Fig. 24]

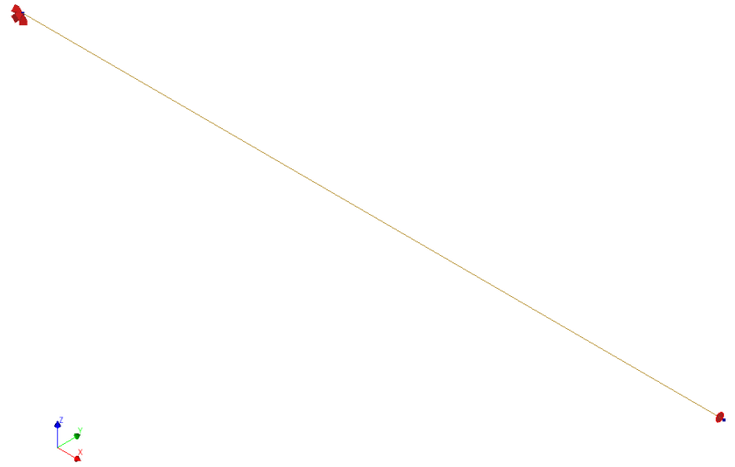


Figure 22: Geometry view

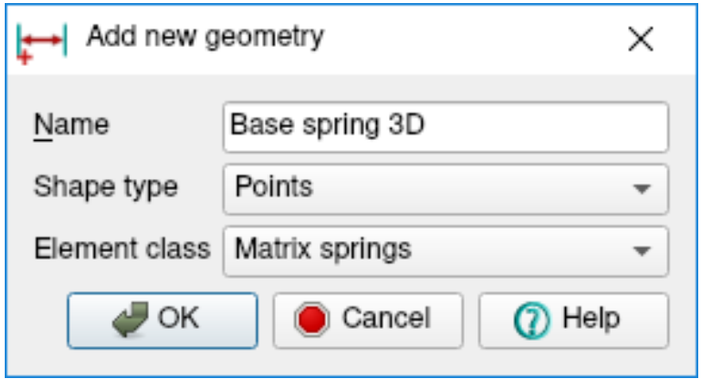


Figure 23: Add new geometry - base spring

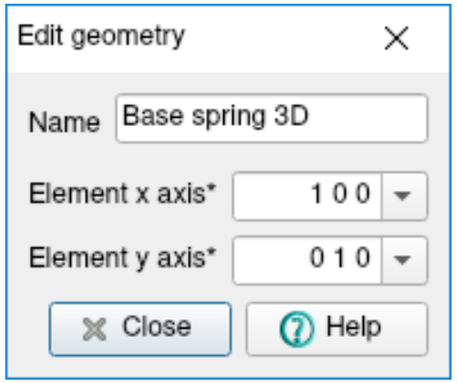


Figure 24: Edit geometry - base spring

We generate the mesh and on the element types of the mesh browser in DIANAIE we can see the spring type N6SPR, which is a one-node directly integrated spring element used in three-dimensional models [Fig. 27].

DIANAIE

Main menu → Geometry → Mesh → Generate mesh [Fig. 25] [Fig. 26]

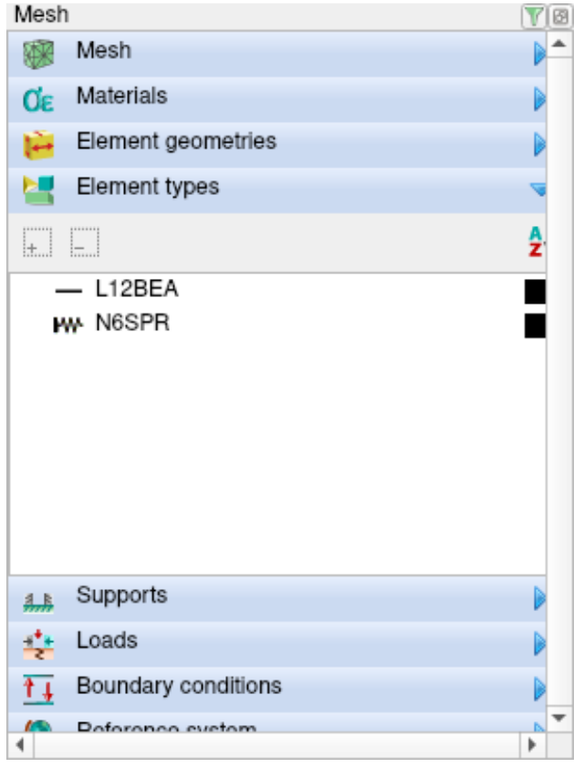


Figure 25: Mesh browser - element types

Figure 26: Finite element mesh

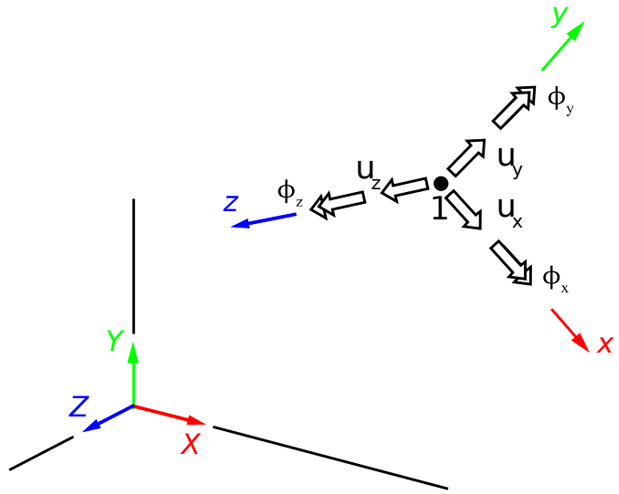


Figure 27: Spring element N6SPR

4 Open Springs

We now create two-node discrete springs between two vertices of the model [Fig. 1a]. For that we make other beam distanced from the first one from 0.5 m in the X direction. With this configuration we can create two-node discrete springs with open mode. Open mode is used when two vertices connected by the spring are located apart from each other.

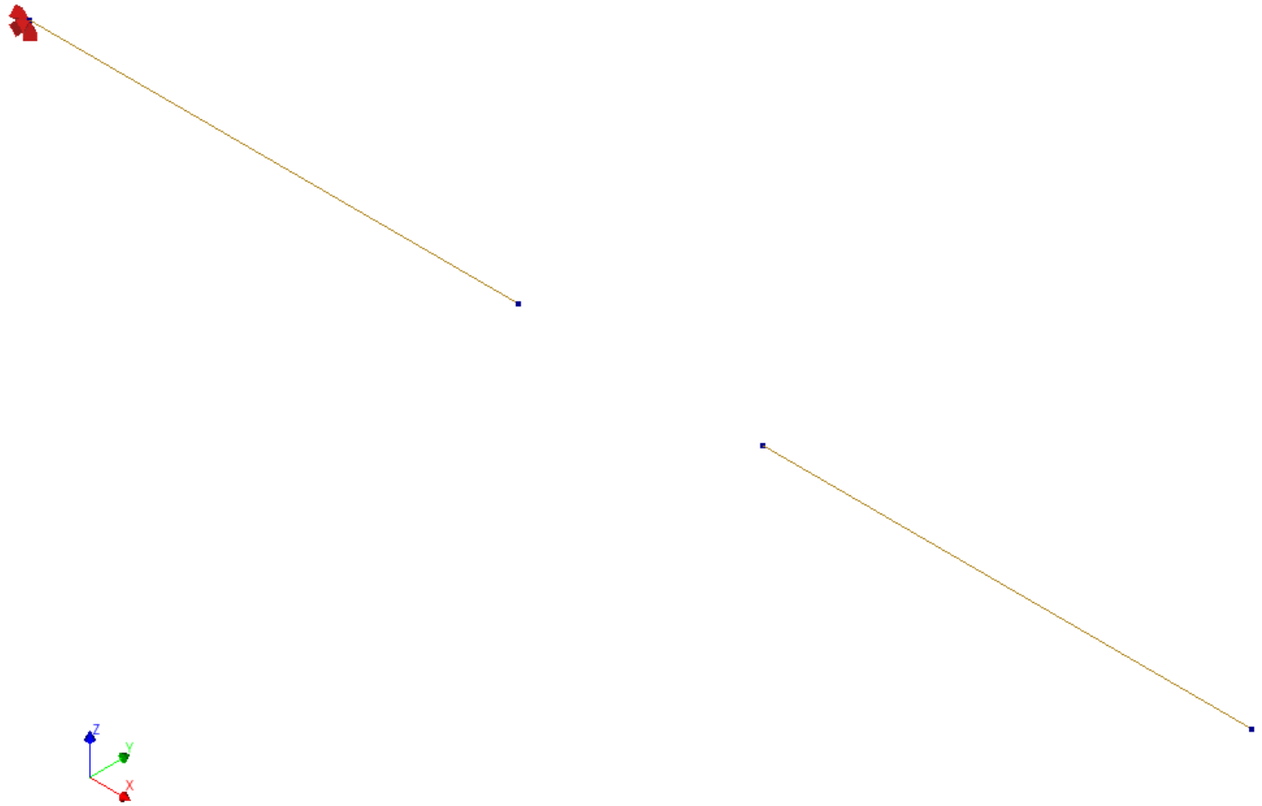


Figure 28: Model with two beams

4.1 Translational Spring

We define a connection between the two closest vertices of the beams to create a two-node spring with a discrete translation spring/dashpot element. We use the same material model used in the boundary spring [Section 3.1] ([Fig. 6] [Fig. 7]). We define the free end of the clamped beam as the source point and the closest end of the free beam as the target point [Fig. 30]. We select the mode as *open*.

DIANAIE

Main menu → Geometry → Assign → Connections [Fig. 29]

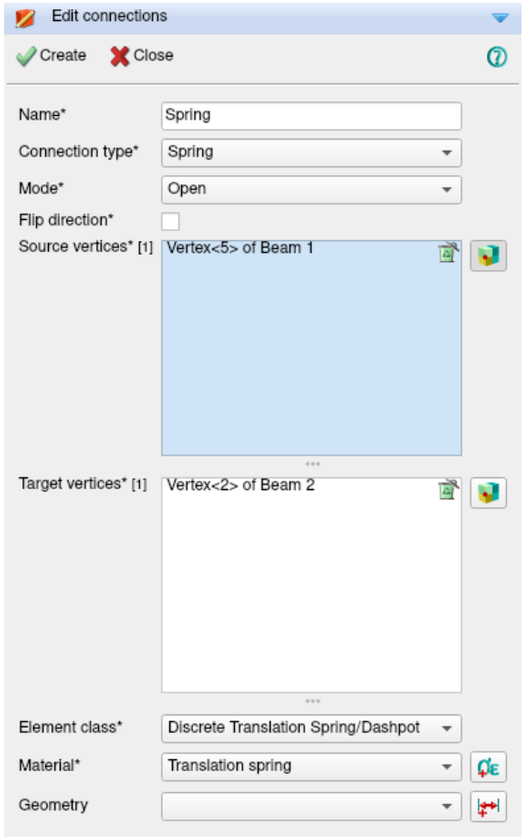


Figure 29: Spring connection

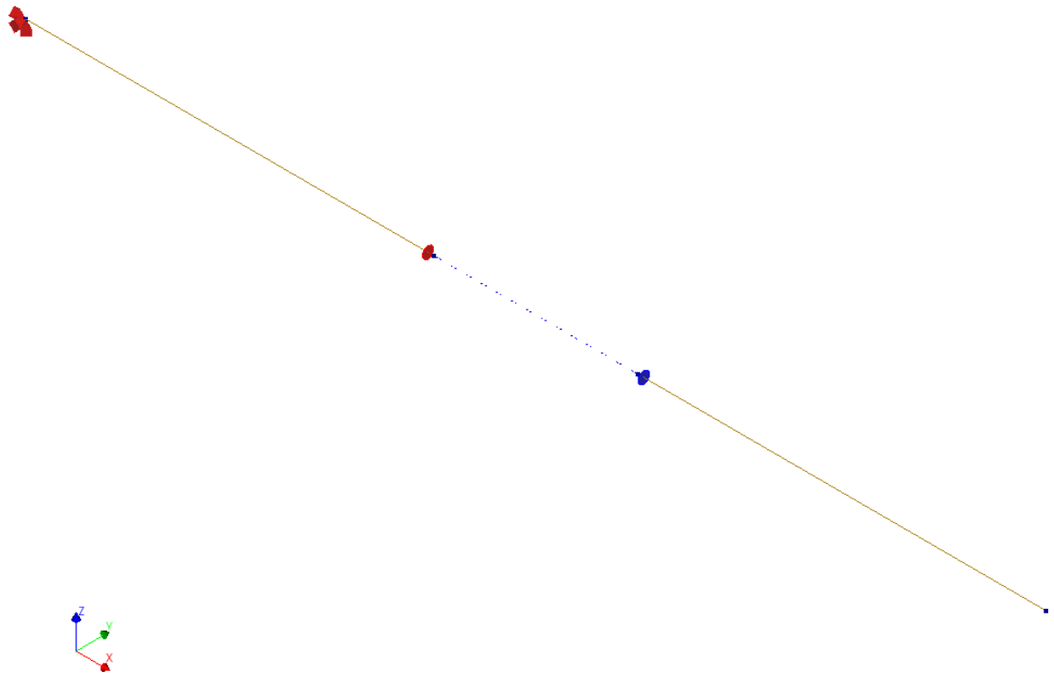


Figure 30: Source and target points for the spring

We now generate the mesh. In the element types of the mesh browser in DIANAIE we can see the spring type SP2TR which is a two-node translation spring/dashpot element defined in two vertices [Fig. 33] .

DIANAIE

Main menu → Geometry → Mesh → Generate mesh [Fig. 9] [Fig. 10]

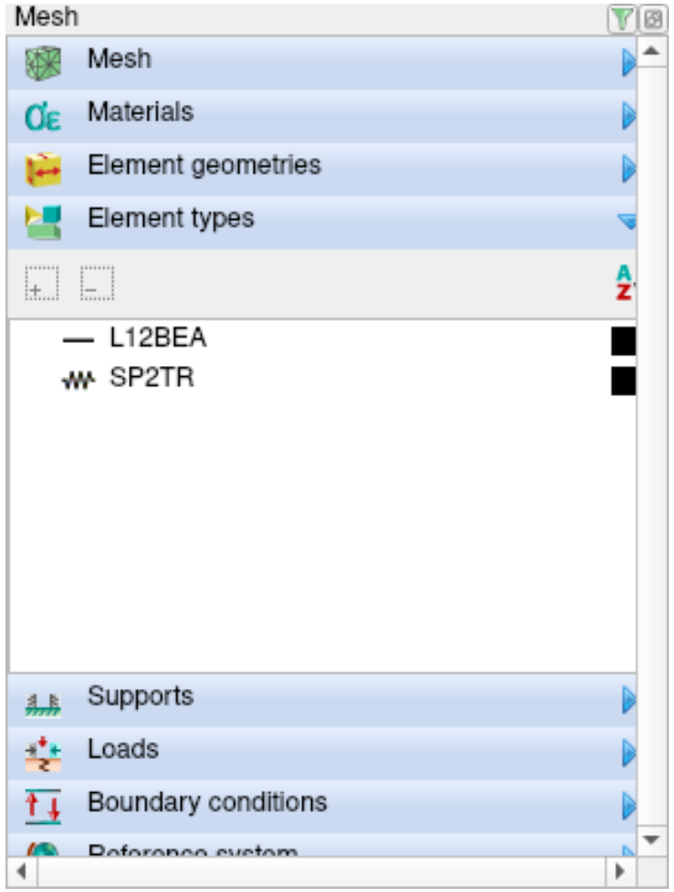


Figure 31: Mesh browser - element types

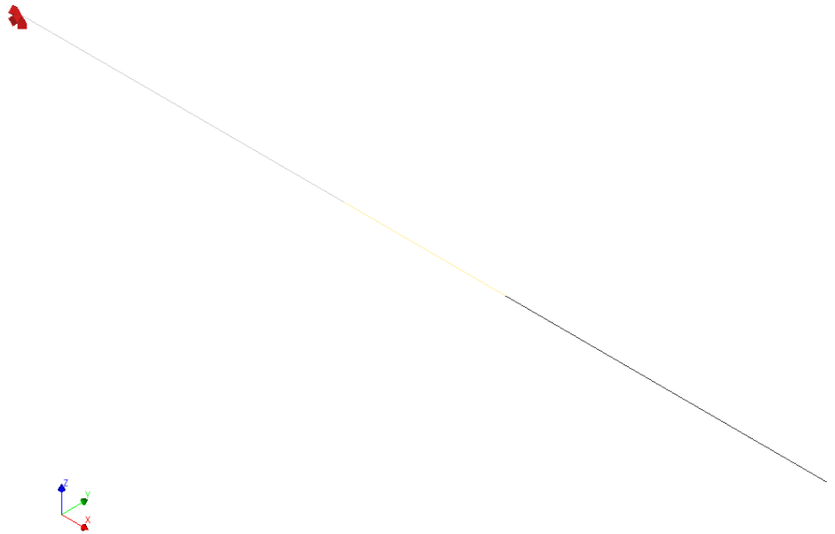


Figure 32: Finite element mesh

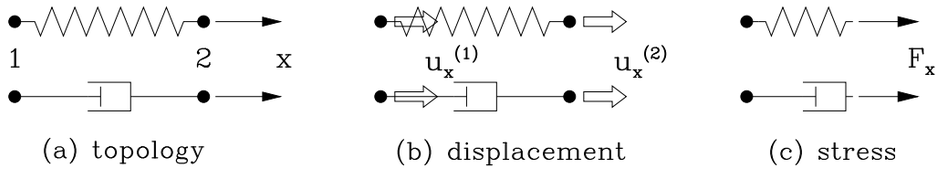


Figure 33: Spring element SP2TR

4.2 Rotational Spring

We define the same spring but now with a discrete rotation spring/dashpot element. We use the same material model used in the boundary spring [Section 3.2] ([Fig. 13] [Fig. 14]).

DIANAIE

Main menu → Geometry → Assign → Connections [Fig. 34]

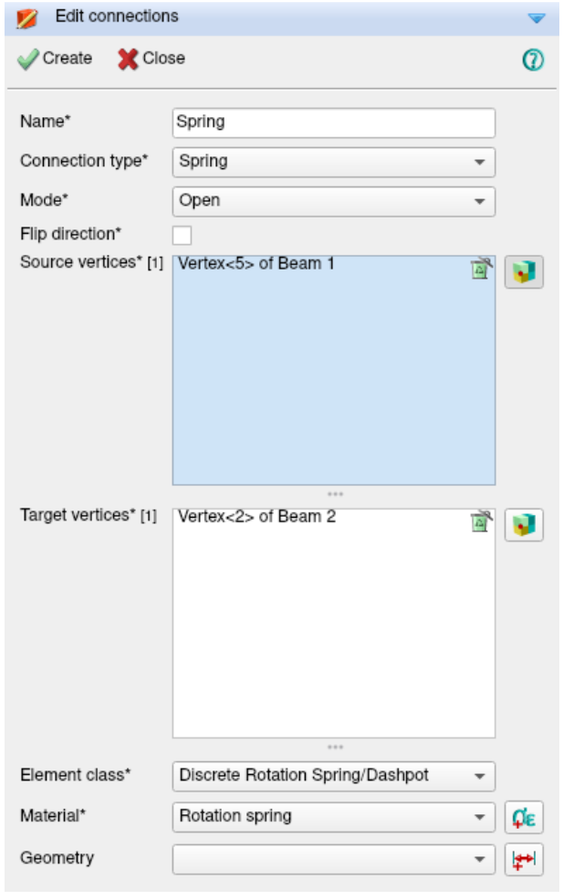


Figure 34: Spring connection

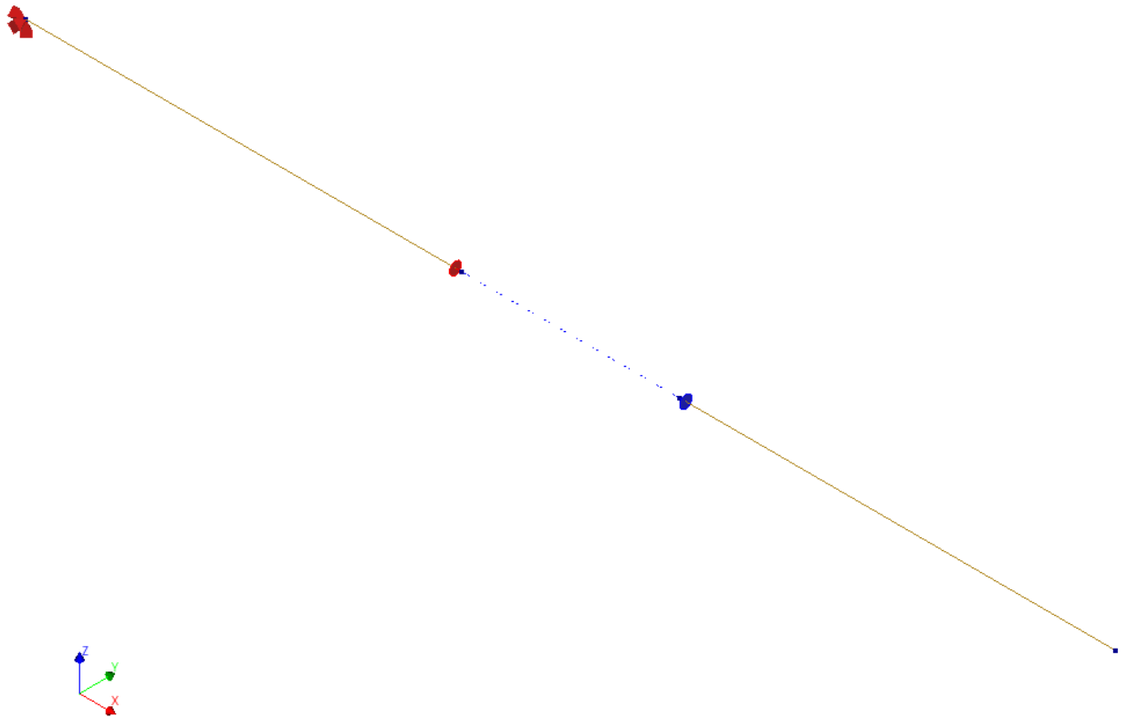


Figure 35: Source and target points for the spring

After defining the spring connection we generate the mesh. In the element types of the mesh browser in DIANAIE we can see the spring type SP2RO which is a two-node rotation spring/dashpot element defined in two vertices (free end of the beam) [Fig. 38].

DIANAIE

Main menu → Geometry → Mesh → Generate mesh [Fig. 36] [Fig. 37]

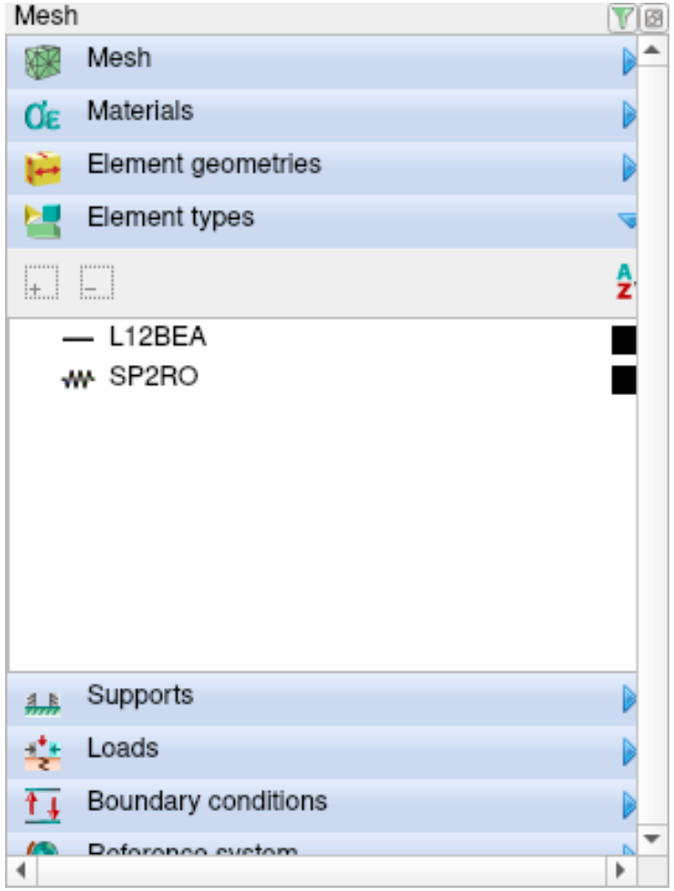


Figure 36: Mesh browser - element types

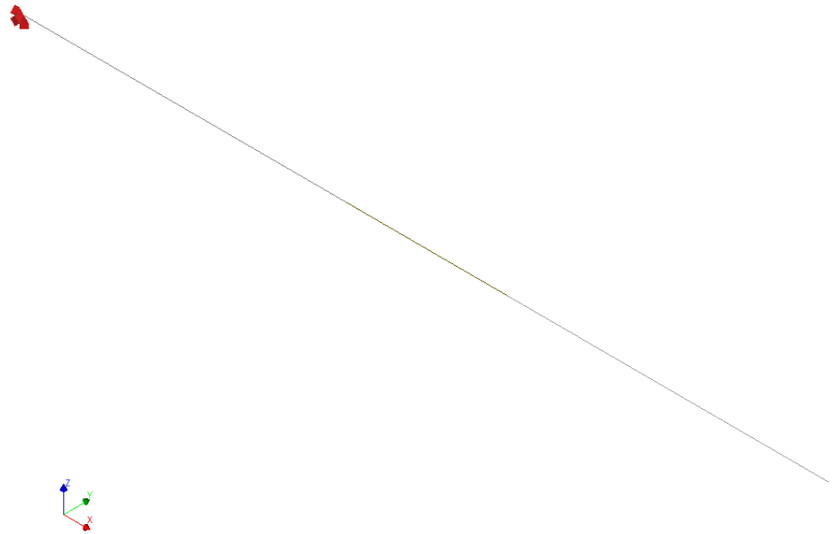


Figure 37: Finite element mesh

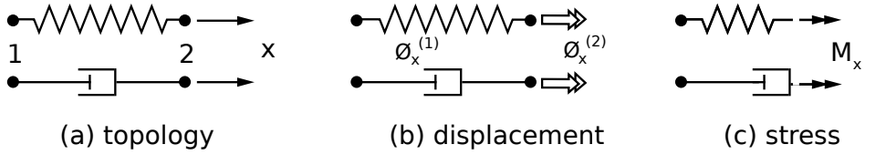


Figure 38: Spring element SP2RO

4.3 Base Spring

We now define a base spring between the same two vertices. With this we create a three dimensional base spring element which is commonly used to model springy translational and rotational behavior of supports in frame structures. We use the same material and geometrical models used in the boundary spring [Section 3.3] ([Fig. 20 to 24]).

DIANAIE

Main menu → Geometry → Assign → Connections  [Fig. 39]

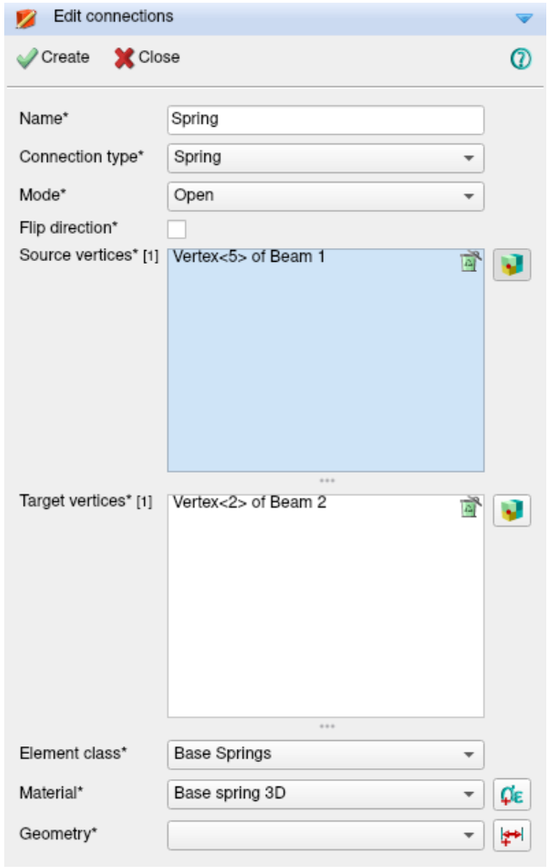


Figure 39: Spring connection

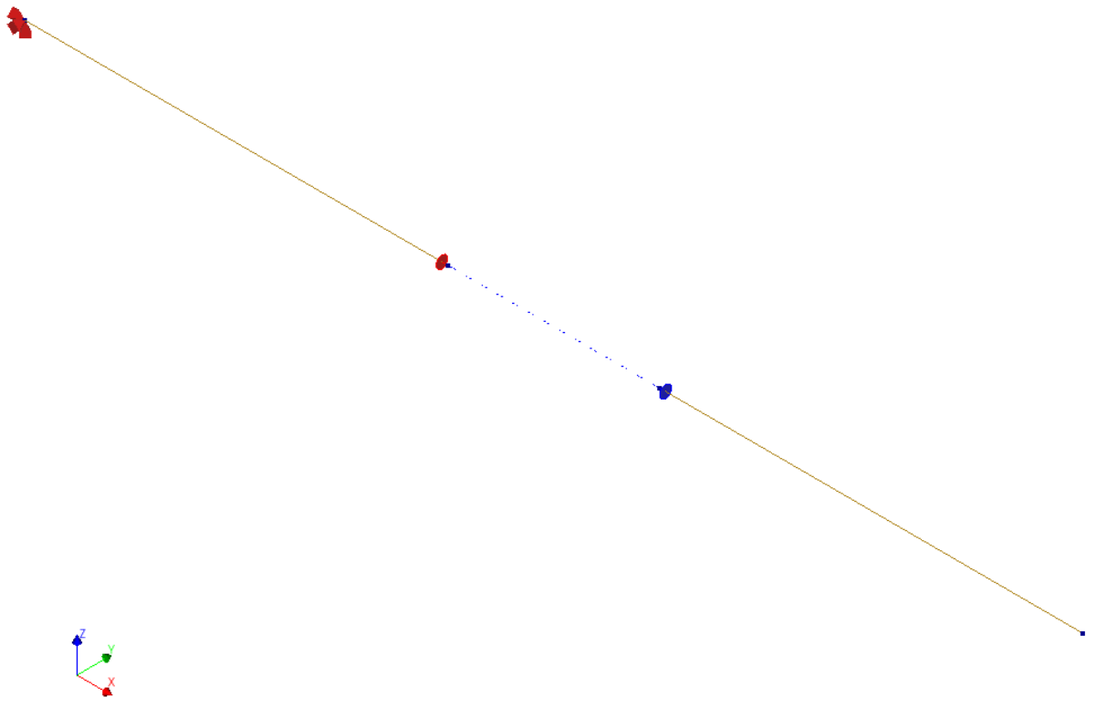


Figure 40: Source and target points for the spring

We generate the mesh. In the element types of the mesh browser in DIANAIE we can see the spring type SP12BA which is a two-node directly integrated base spring element [Fig. 43].

DIANAIE

Main menu → Geometry → Mesh → Generate mesh [Fig. 41] [Fig. 42]

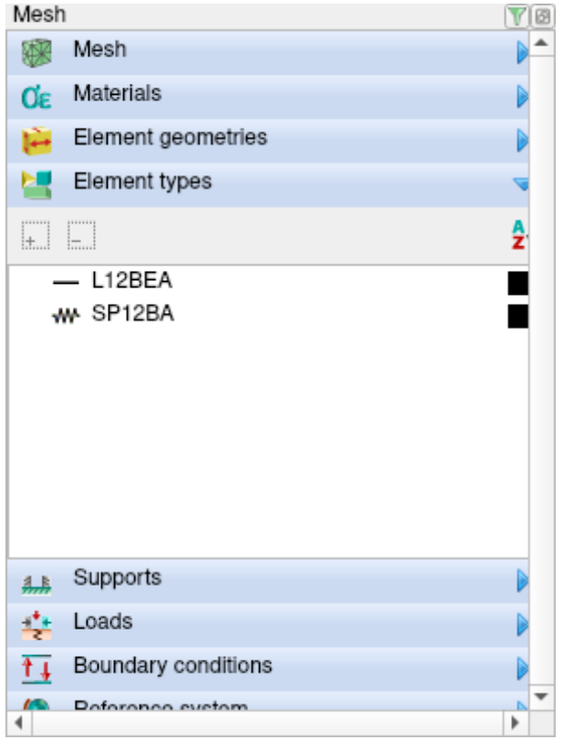


Figure 41: Mesh browser - element types

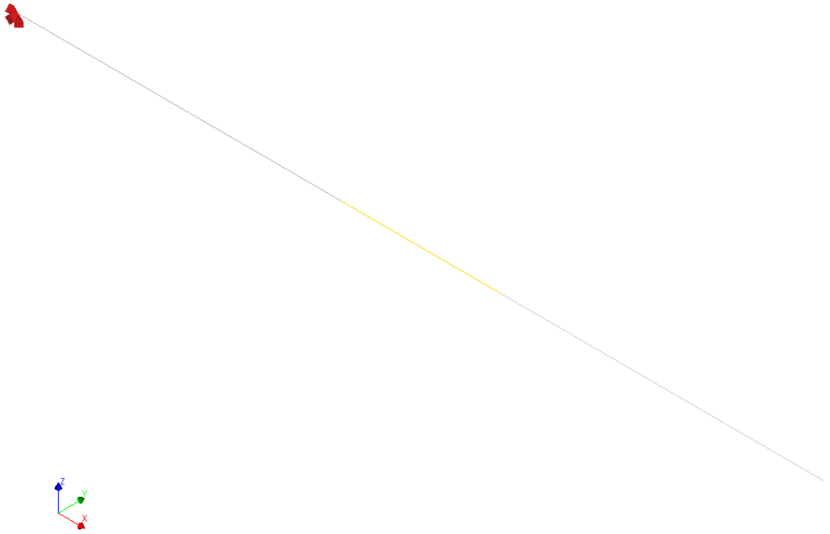


Figure 42: Finite element mesh

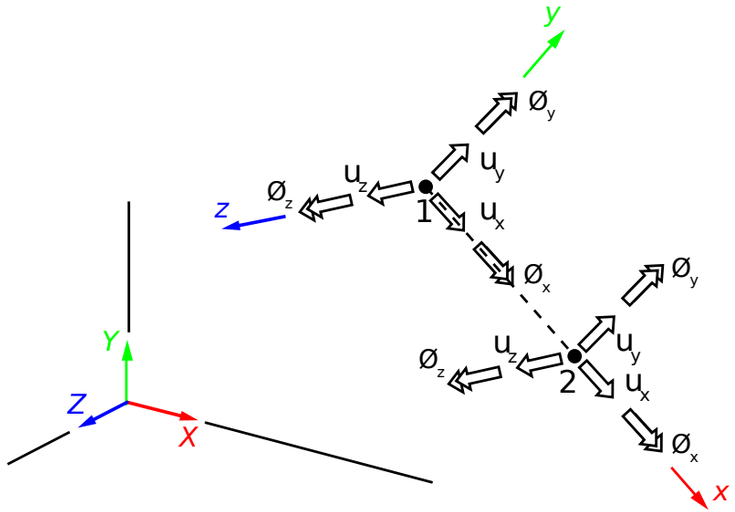


Figure 43: Spring element SP12BA

5 Closed Springs

We now move the second beam -0.5 m in the X direction such that the two vertices are coincident. We now create closed springs between the two nodes.

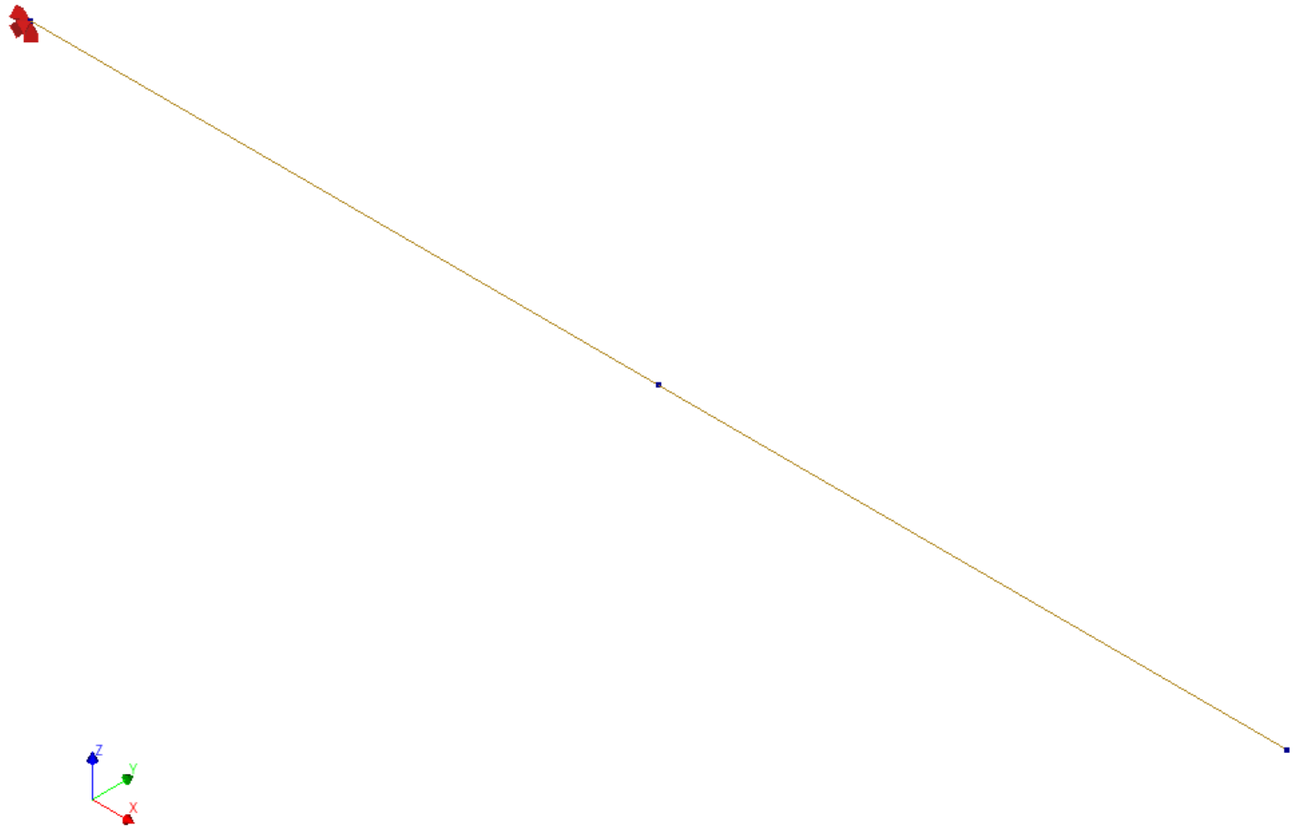


Figure 44: Model with two beams with coincident vertices

We exemplify the closed two-node spring with a discrete translational spring[5]. We define the free end vertice of the clamped beam as the source point and the coincident vertice of the second beam as target point for the spring. We set the mode as *close*. We use the same material model for translation spring/dashpot defined for the boundary spring [Section 3.1] [Fig. 6] [Fig. 7].

DIANAIE

Main menu → Geometry → Assign → Connections  [Fig. 45]

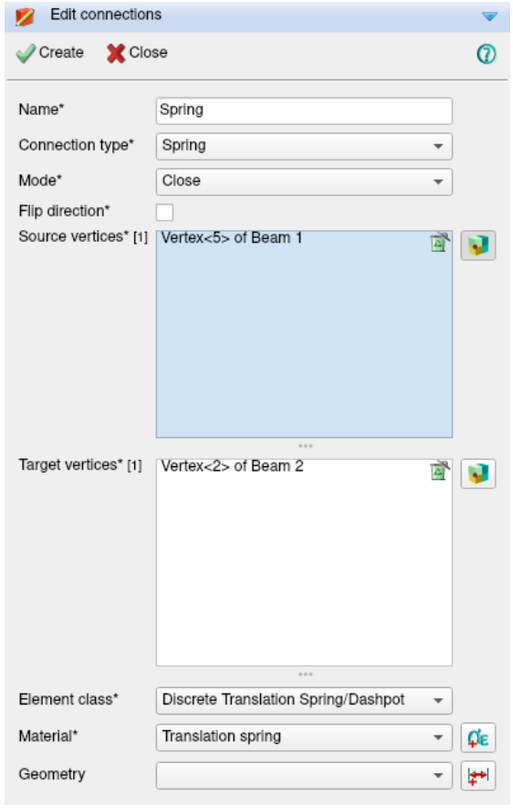


Figure 45: Spring connection

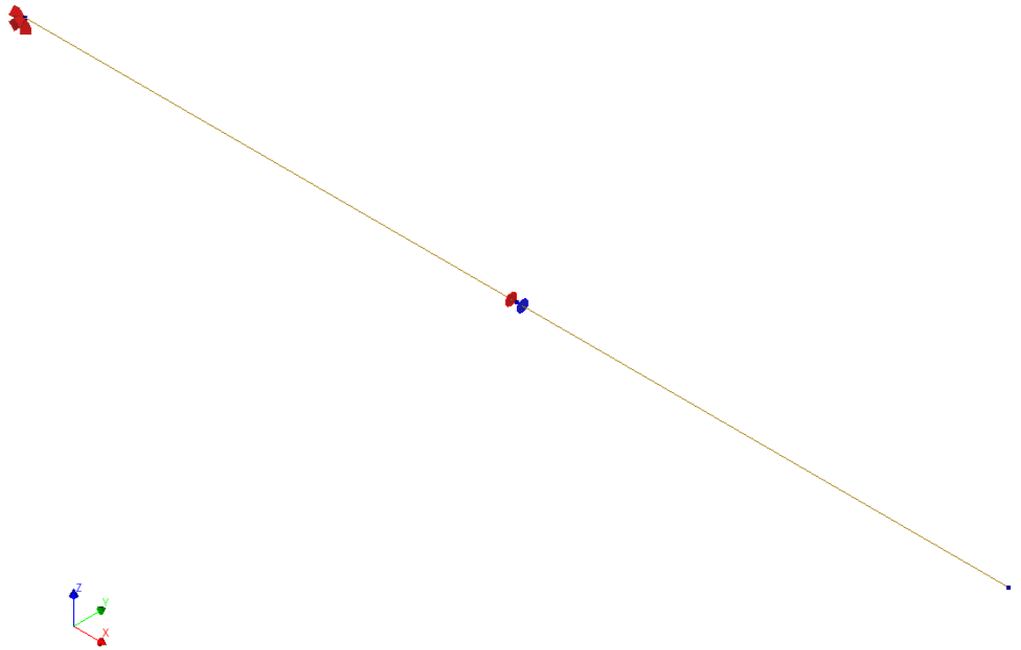


Figure 46: Source and target points for the spring

[5]All the other spring elements referred in [Section 4] can be used as closed springs

After defining the spring connection we generate the mesh. In the element types of the mesh browser in DIANAIE we can see the spring type SP2TR.

DIANAIE

Main menu → Geometry → Mesh → Generate mesh [Fig. 47] [Fig. 48]

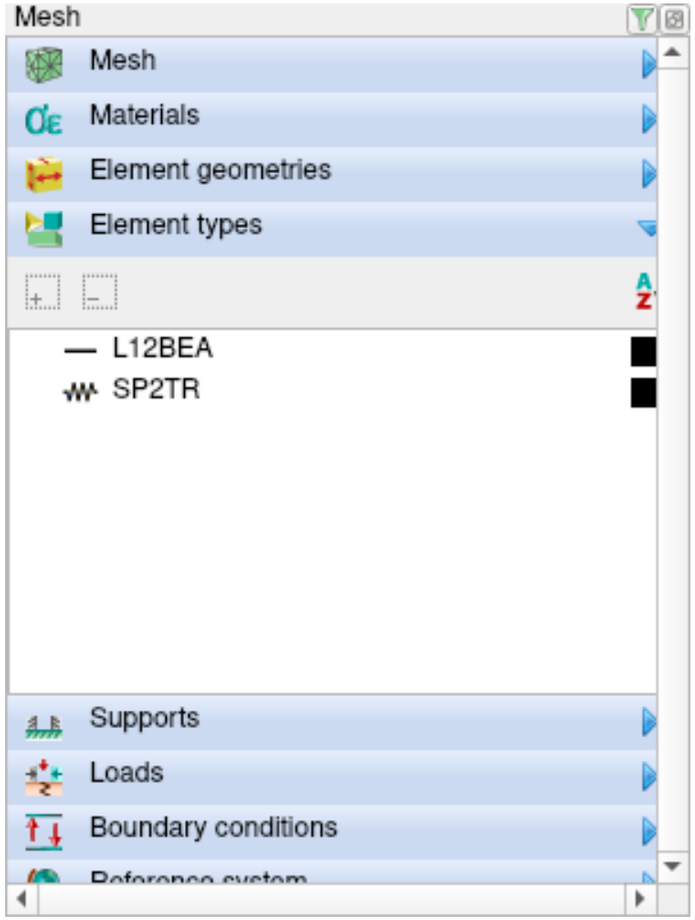


Figure 47: Mesh browser - element types

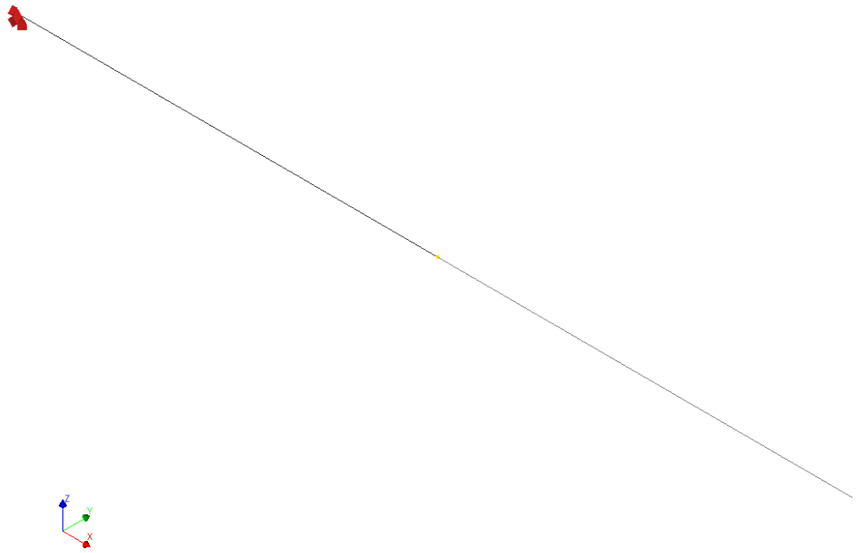


Figure 48: Finite element mesh

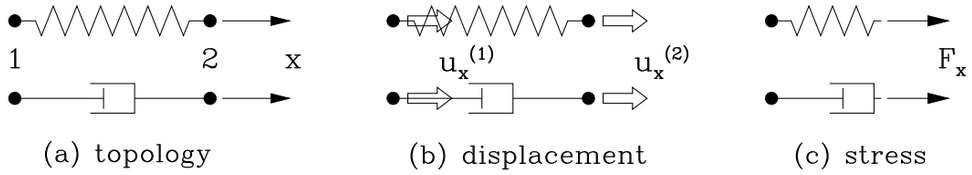


Figure 49: Spring element SP2TR

If we select the option *flip direction* the source and target points swap. So, in this case, the free end vertice of the clamped beam is the target point and the coincident vertice of the second beam is the source point.

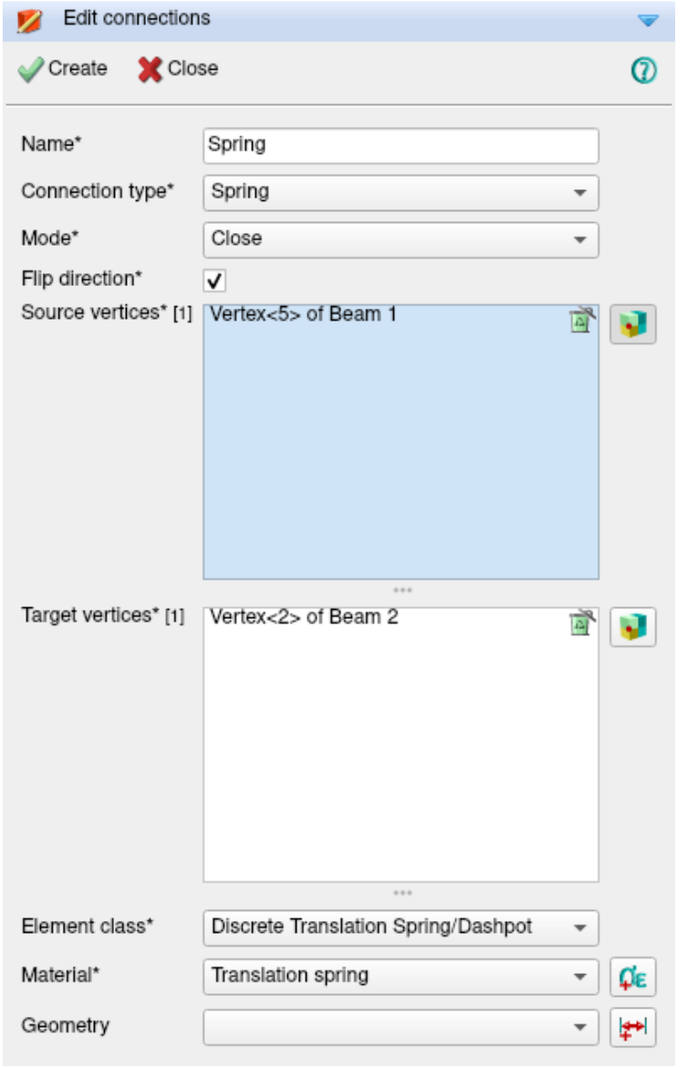


Figure 50: Spring connection

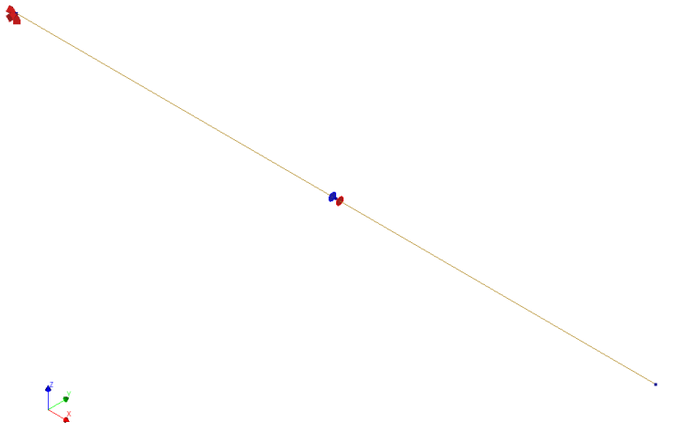


Figure 51: Source and target points for the spring

Appendix A Additional Information

Folder: Tutorials/SpringElements

Number of elements ≈ 5

Keywords:
CONSTR: suppor.
ELEMEN: beam circle class3 l12bea sp1tr spring.
MATERI: concre elasti mc2010 spring unload.

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