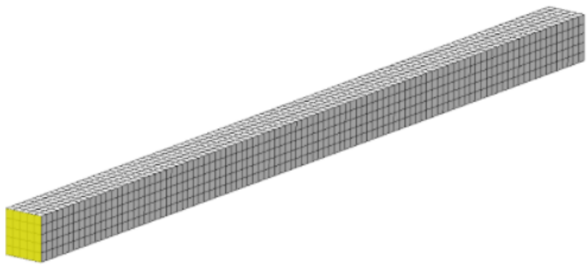

MODAL ANALYSIS OF A BEAM

Application Note

f_n

Objectives:

- Perform modal analysis (Linear Eigenvalue Problem) of a cantilever beam in Akselos Modeler.
- Find the first three natural frequencies and mode shapes of the beam, then compare with theory.

Model Description:

The model below is a finite element representation of a cantilever beam pinned at both ends. Dimensions of this beam and materials are shown in the picture below.

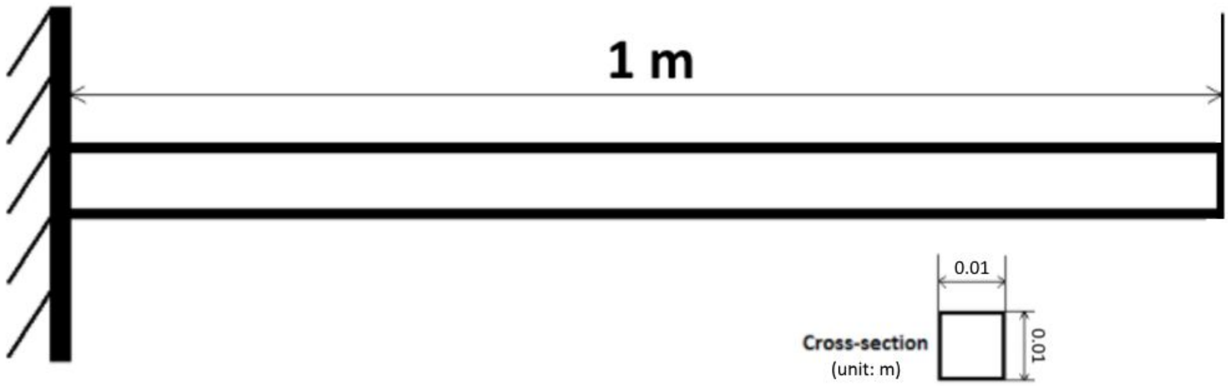

Figure 1: Model schematic.

Model Properties:

Elastic Modulus	206.8 GPa
Poisson Ratio	0.00
Density ρ	7830 kg/m^3

Table 1: Model Properties

<u>Hand Calculations</u>

Based on Roark's Formula for Stress and Strain (7th edition), Equation 3b from Table 16.1, Chapter 16, page 765, we have:

$$f_n = \frac{K_n}{2\pi}\sqrt{\frac{EIg}{\omega l^4}}$$

Where:

- K_n is a constant where n refers to the mode of vibration;

- ω is load per unit length including beam weight (Newtons/metre)

$$\omega = \rho g A$$

Hence:

$$f_n = \frac{K_n}{2\pi}\sqrt{\frac{206.8\times10^9\times\frac{0.01^4}{12}\times9.81}{7830\times9.81\times0.01^2\times1^4}} = 2.36115\ K_n$$

Based on Roark, we have values of K_n, then we can calculate f_n.

Mode	K_n	f_n (Hz)
1	3.52	8.311
2	22.0	51.945
3	61.7	145.683

Table 2: Theory results

STEP 1: Create Elasticity Eigen collection

- In the *Editor* tab, click on *New Collection*.
- Set the collection name.
- Set the *Physics* field on *elasticity_eigen*.

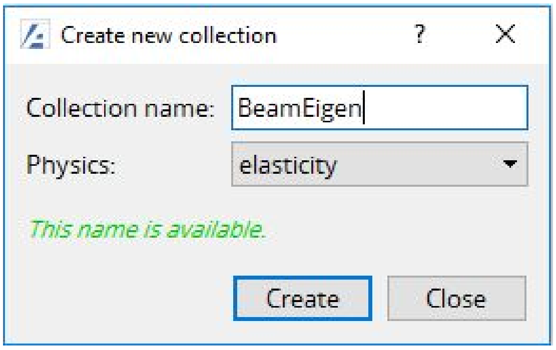

Fig. 2: New elasticity_eigen collection

- Upload the collection to Akselos Server.
- Import the collection to your computer.

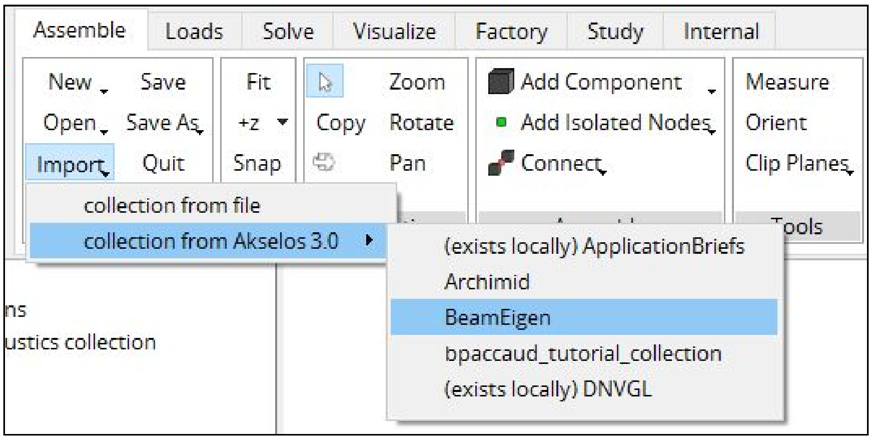

Fig. 3: Import the collection

STEP 2: Create components

- Create components in Akselos Modeler from exiting mesh files. (Refer to the Component Editor tutorials in the Akselos User Manuals for a step-by-step tutorial on how to create components.)
- In this case, we use mesh size 1mm x 1mm. The component is 0.2m long.

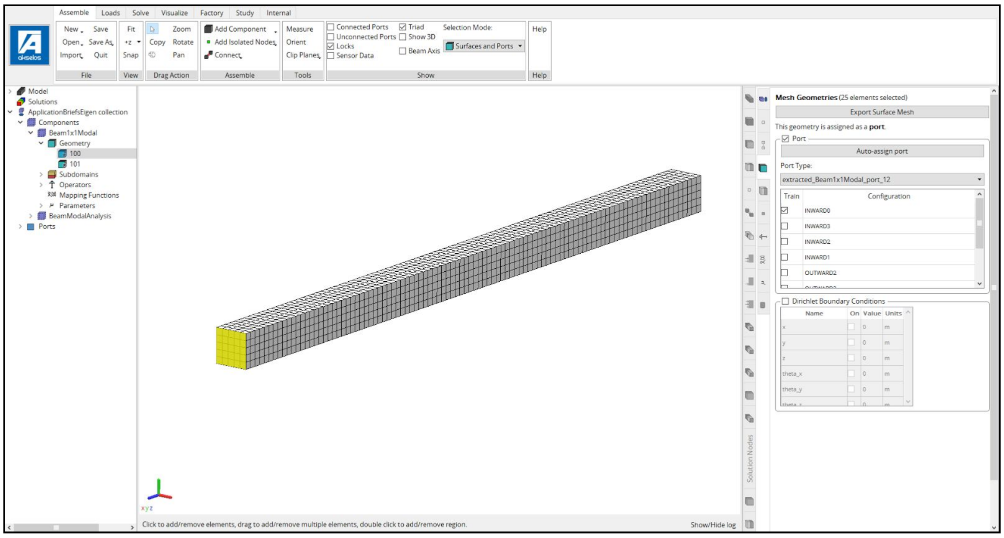

Fig. 4: New component in Akselos Modeler

STEP 3: Assemble the model

- Assemble 5 components, 0.2m each, to create a beam model that is 1m long. (Refer to Akselos Basic tutorials in the Akselos User Manuals for a step-by-step tutorial on how to assemble and align a model correctly.)

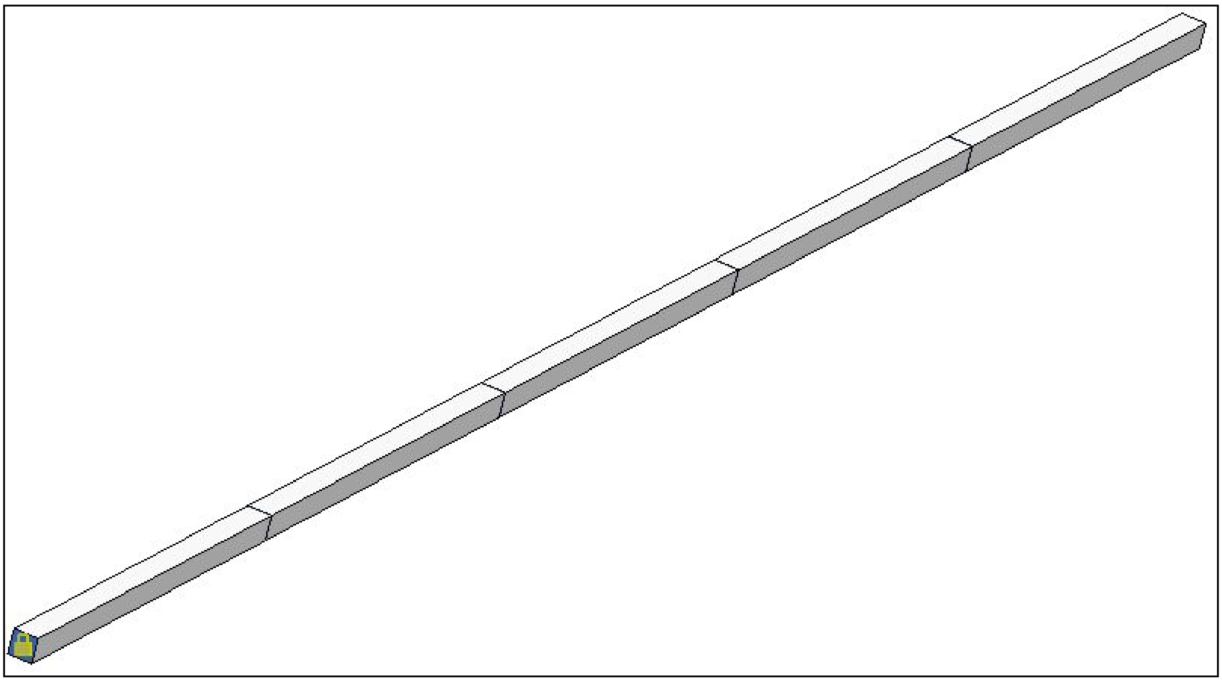

Fig. 5: Cantilever beam model in Akselos Modeler

STEP 4: Solve the model

- Upload the model to Akselos server. (Refer to the Component Editor tutorials in the Akselos User Manuals for a step-by-step tutorial.)

You can then solve with the FEA solver straight away. If you want to solve using the RB-FEA solver, you have to train the model first using the Akselos Web Dashboard.

- In the *Solve* tab, choose *Solver Options.* Then set the *Number of eigenvalues*. Because this model is symmetric in xz and xy planes, you have to solve 6 eigenvalues because you have pairs of modes with the same value.
- You should obtain the following results:

Mode	f_n (Hz) theory	f_n (Hz) Akselos	Mismatch (%)
1	8.311	8.384	0.877
2	51.945	52.521	1.109
3	145.683	146.970	0.883

Table 3: Results in Akselos Modeler compared with theory

To obtain accurate higher mode frequencies, this mesh would have to be refined even more, i.e. instead of 1mm x 1mm elements, you would have to model the cantilever beam using 0.5mm x 0.5mm elements or more depending on the highest frequency mode of interest.

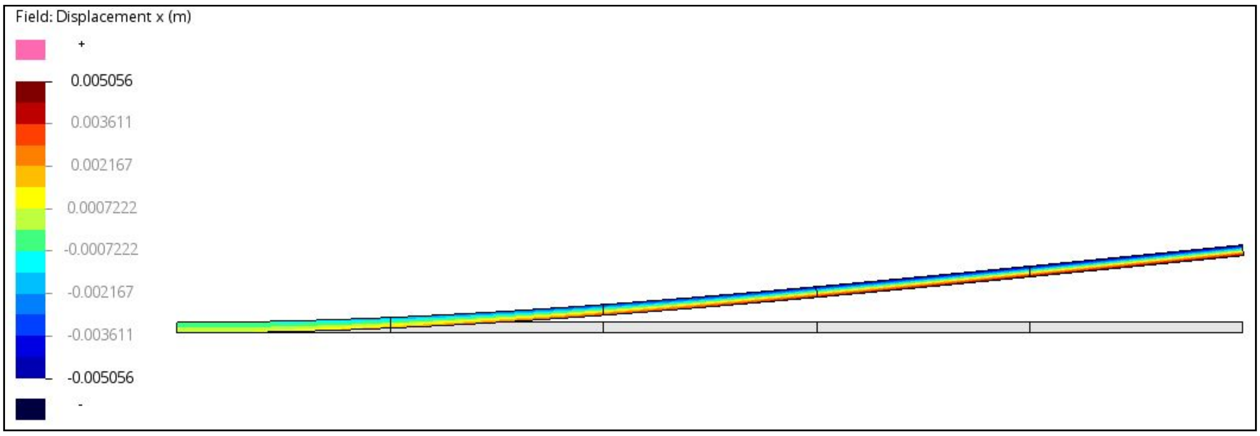

Fig. 6: Mode 1 result

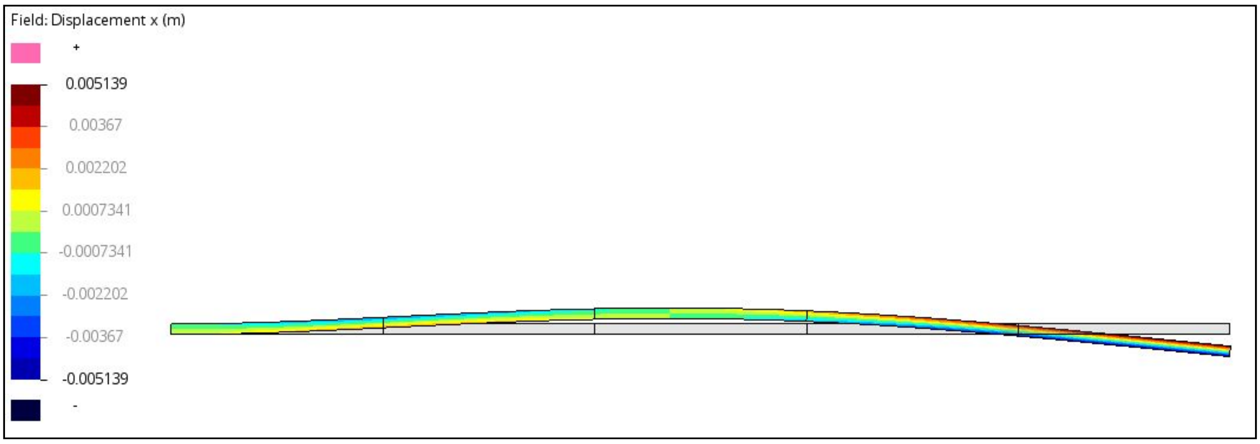

Fig. 7: Mode 2 result

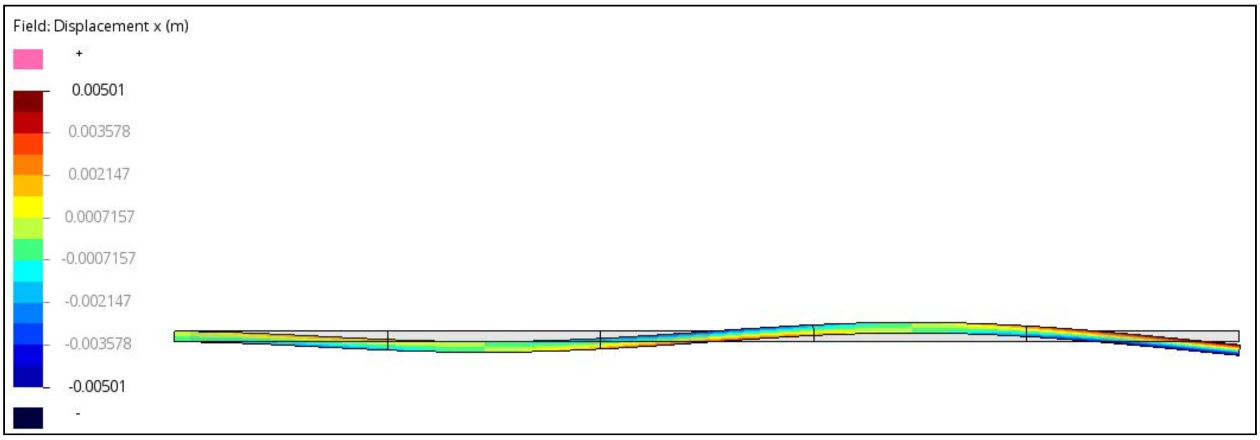

Fig. 8: Mode 3 result

About Akselos

Akselos is a digital technology company headquartered in Switzerland, with operations in Europe, the USA and South East Asia. The company has created the world's most advanced engineering modeling, and fastest simulation technology, to protect the world's critical infrastructure today and tomorrow. The technology has the power to revolutionize how we build and manage our critical infrastructure, and pushes the boundaries of what modern engineering and data analytics can achieve. Developed by some of the world's best minds, the MIT-licensed technology builds something far beyond the capability of a conventional digital twin – a digital guardian that allows operators to not only monitor an asset's condition in real time, but helps them to see the future.

AKSELOS

North America

AKSELOS, Inc
210 Broadway, #201 |
Cambridge,
MA | 02139, USA

Europe/Middle East/Africa

AKSELOS S.A.
EPFL Innovation Park, Building D
1015 Lausanne, Switzerland

Asia-Pacific

AKSELOS Vietnam
125/167 Dinh Tien Hoang
street, Binh Thanh Dist.
Ho Chi Minh city, Vietnam