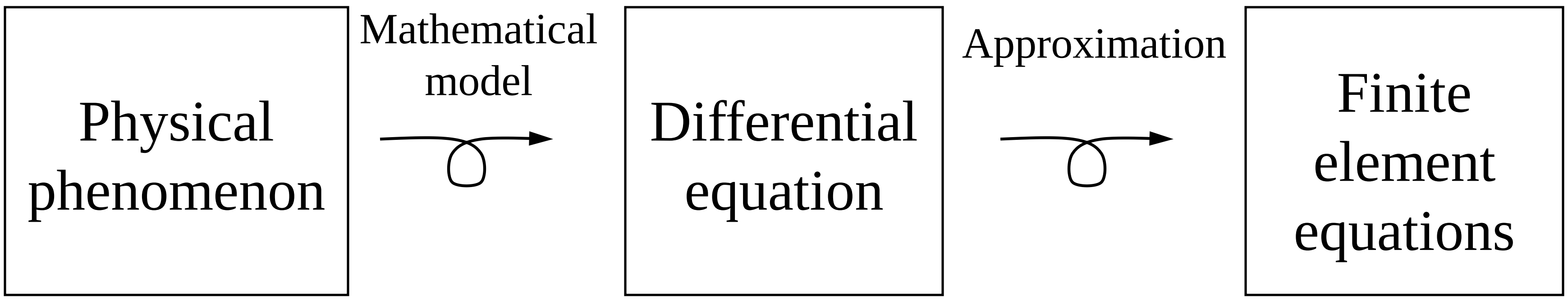
FE-Modelling

To create a simplified model of the

- geometry,
- material,
- loading and
- boundary conditions

that produce results with as small deviations as possible from the real behaviour.

Finite Element Method – FEM



- Deformations
- Heat transfer
- Fluid- or gas flow
- Diffusion
- etc. ...

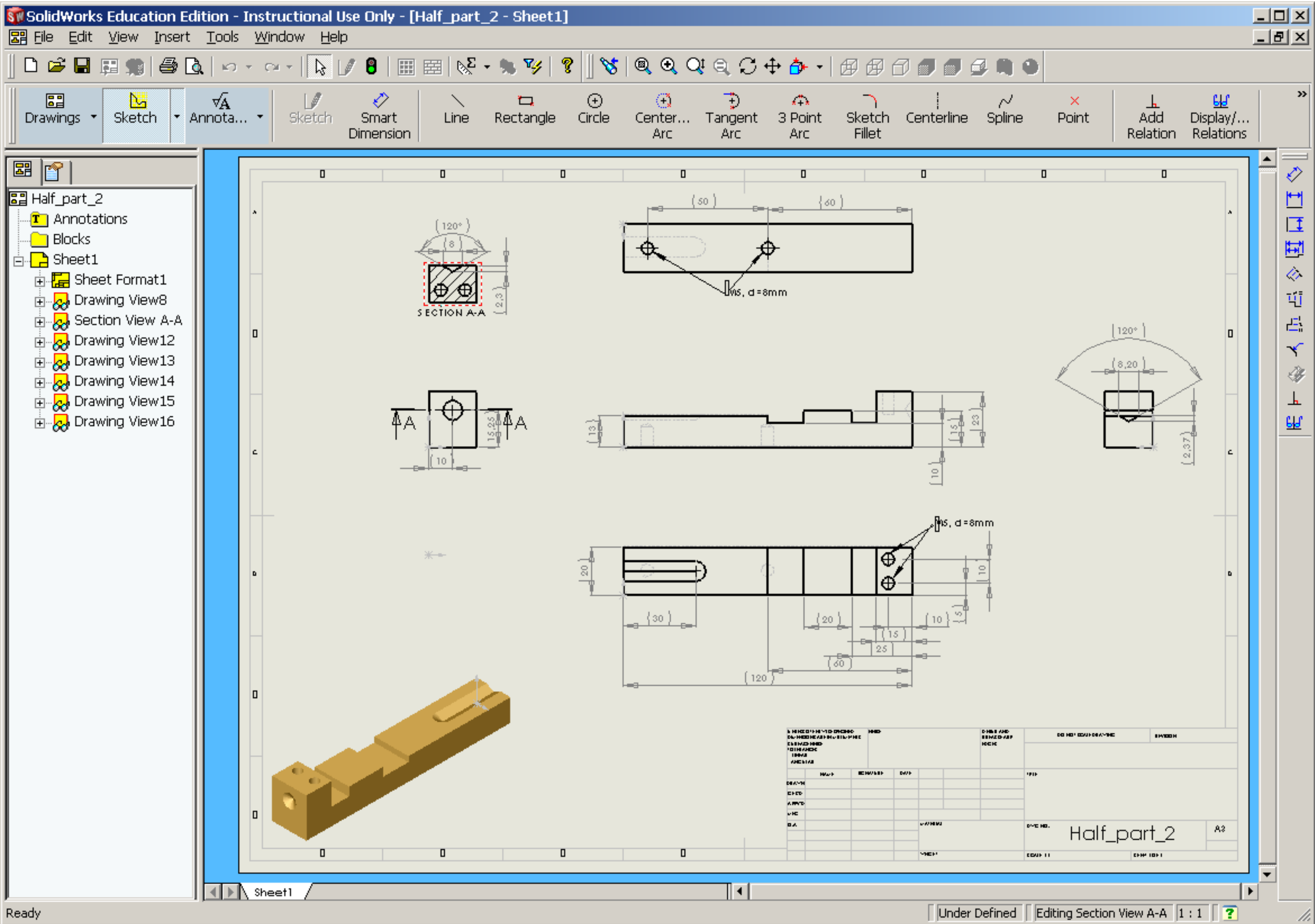
Engineering Computations – FEM

- Modelling
  - Geometry
  - Material
  - Loading, Boundary conditions
- Software
  - Static
  - Dynamic (Implicit, Explicit)
  - Multiphysic (Coupled problems)
- Execution
  - Serial / parallel
- Example

FEM – Work Flow

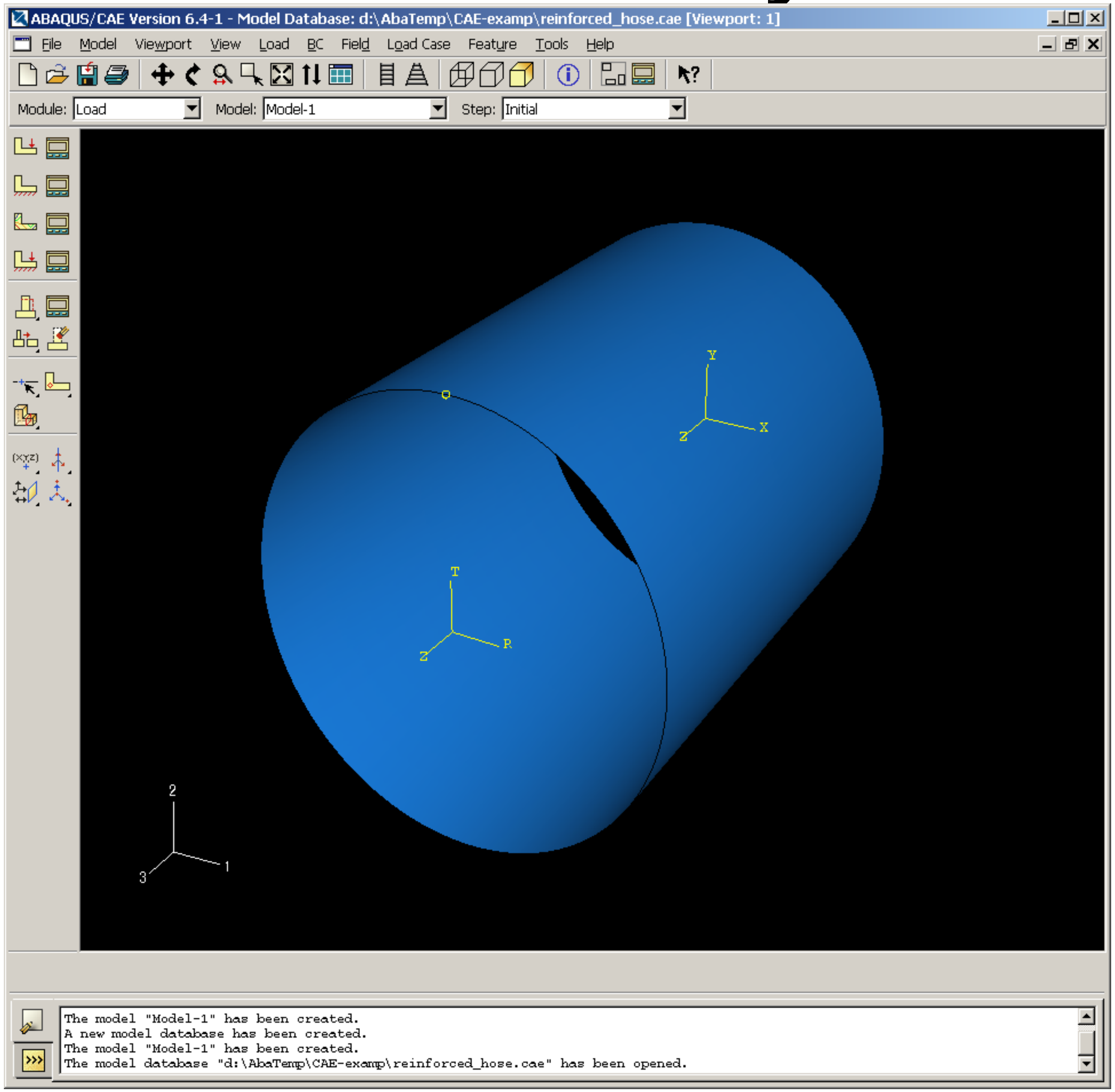
Pre-processor ➡ FE-solver ➡ Post-processor

Geometry



From CAD-software ...

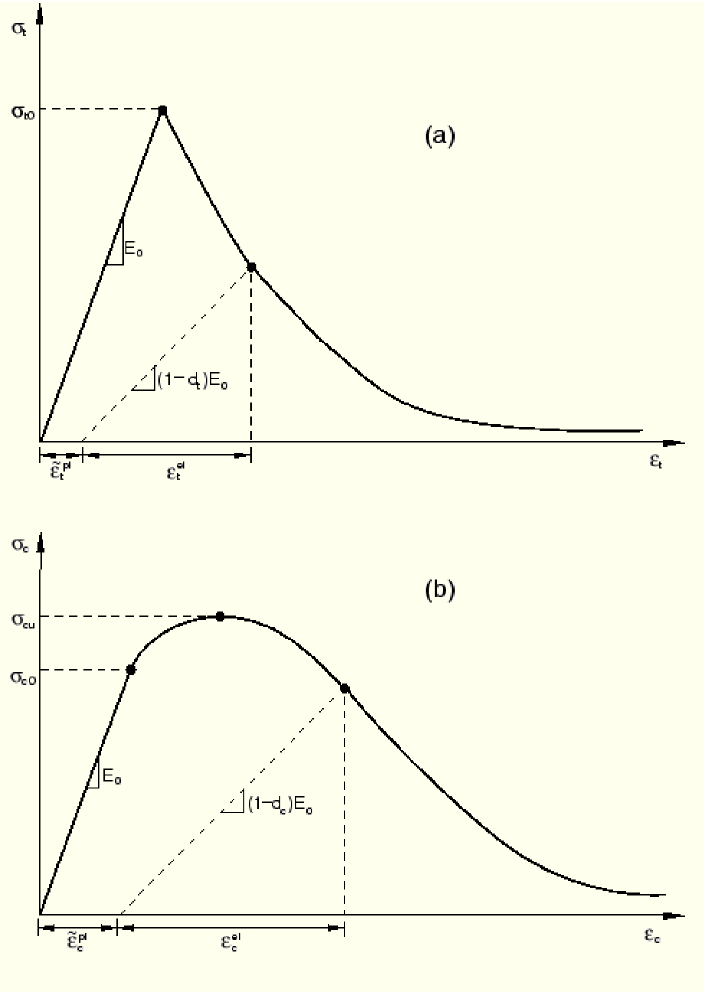
Geometry



... or FE-preprocessor

Material

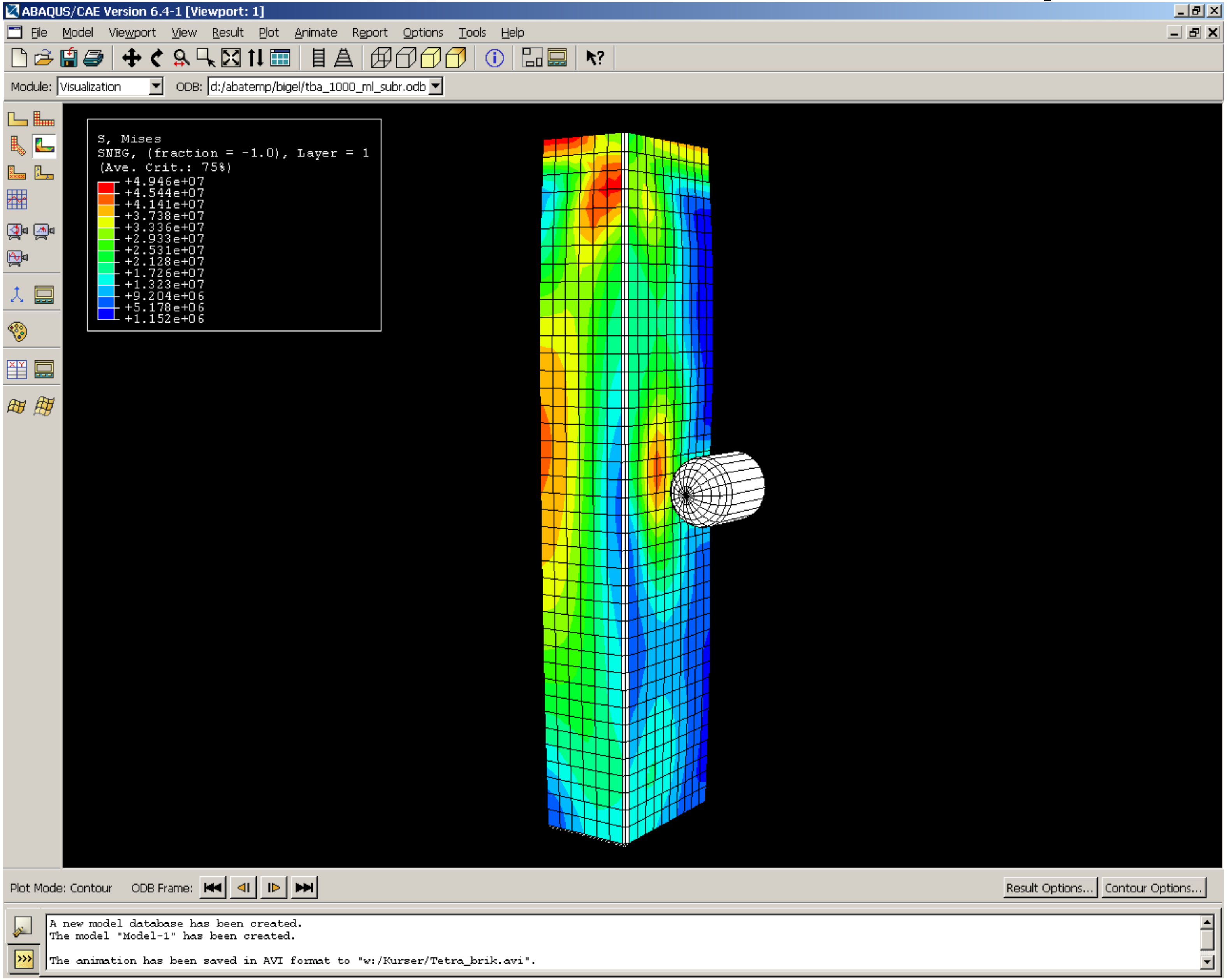
- Isotropic / anisotropic
- Linear
  - Elastic
  - Time dependent, (viscoelastic / creep)
- Non-linear
  - Elastic-plastic
  - Time dependent, (viscoplastic / creep)



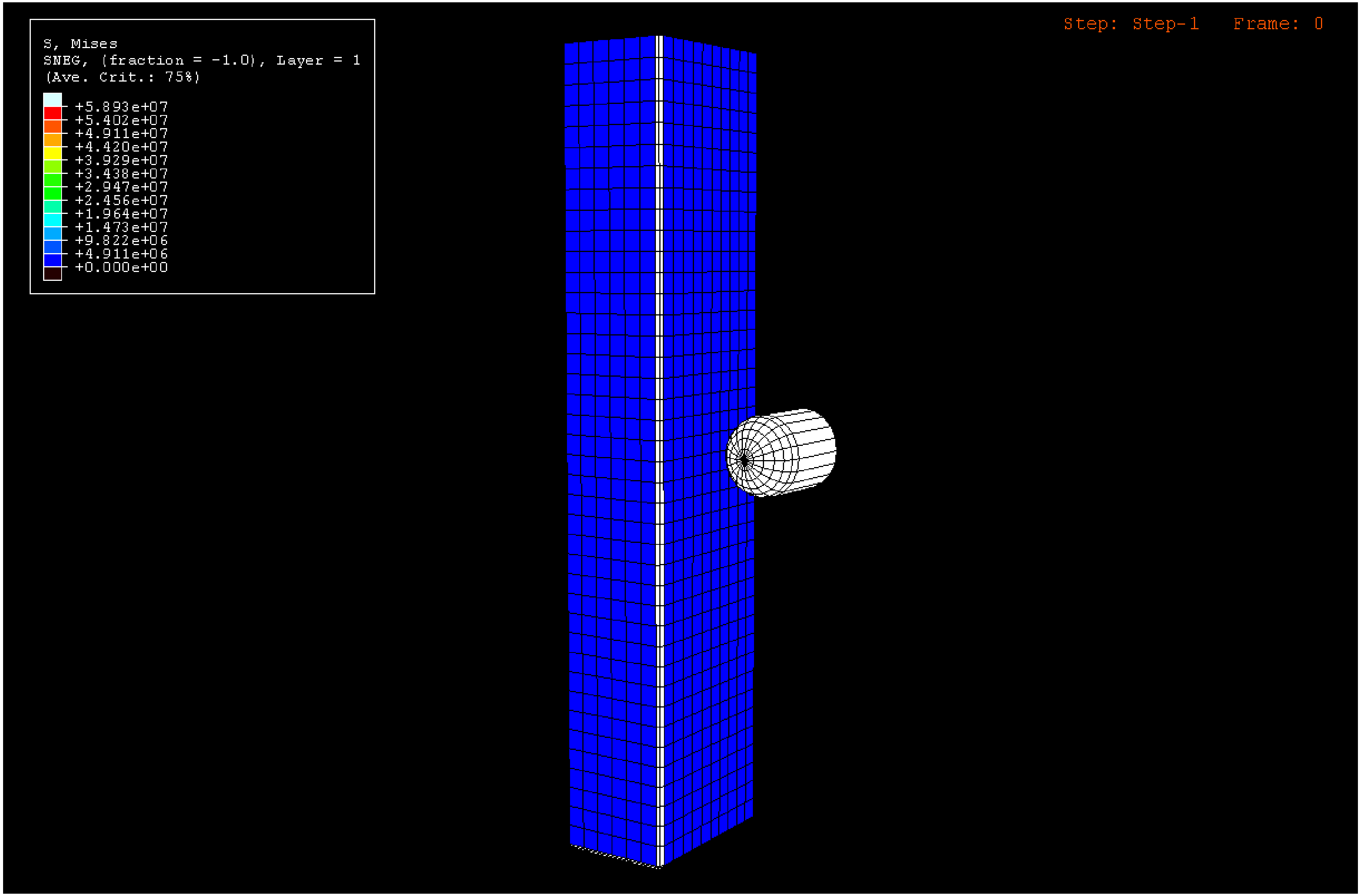
Loading and Boundary Conditions

- Loads
  - Point- , Line-, Surface- and Body-loads
- Boundary displacements
  - Prescribed displacements, constraint equations ...
- Contact
  - Deformable bodies in contact with other deformable- or rigid bodies
- Friction
  - Coulumb, stick-slip ...

Contact conditions - example



Contact conditions - example



Solvers

- Implicit integration in time
  - Direct solution of linear equation system
  - Equilibrium after each time step
  - Large time steps, (unconditional stable)
- Explicit integration in time
  - Solution by determining solution in next time step by only considering the past. (Central difference, Forward Euler method)
  - Contain only matrix and vector multiplications, (lumped mass och linear element approximations)
  - No equilibrium
  - Very small time-steps, (conditional stable)

Solvers

- Implicit method
  - Static or dynamic
    - ABAQUS/Standard
    - NASTRAN
    - Marc
    - Cosmos
    - ...
- Explicit method
  - Dynamic for rapidly changing events (Short time durations)
    - ABAQUS/Explicit
    - Marc
    - LS-Dyna
    - ...

Computer Systems

- Single processor
  - Serial
  - Cheap (or expensive)
- Multiprocessor (Fast internal communication)
  - Serial / Parallel
  - Very expensive (If more than a few processors)
- Cluster (Fairly slow intercommunication)
  - Serial / Parallel
  - Cheap

Lunarc

Alarik:
- 208 nodes
- 16 CPU cores/node
- 32-128 GB ram/node

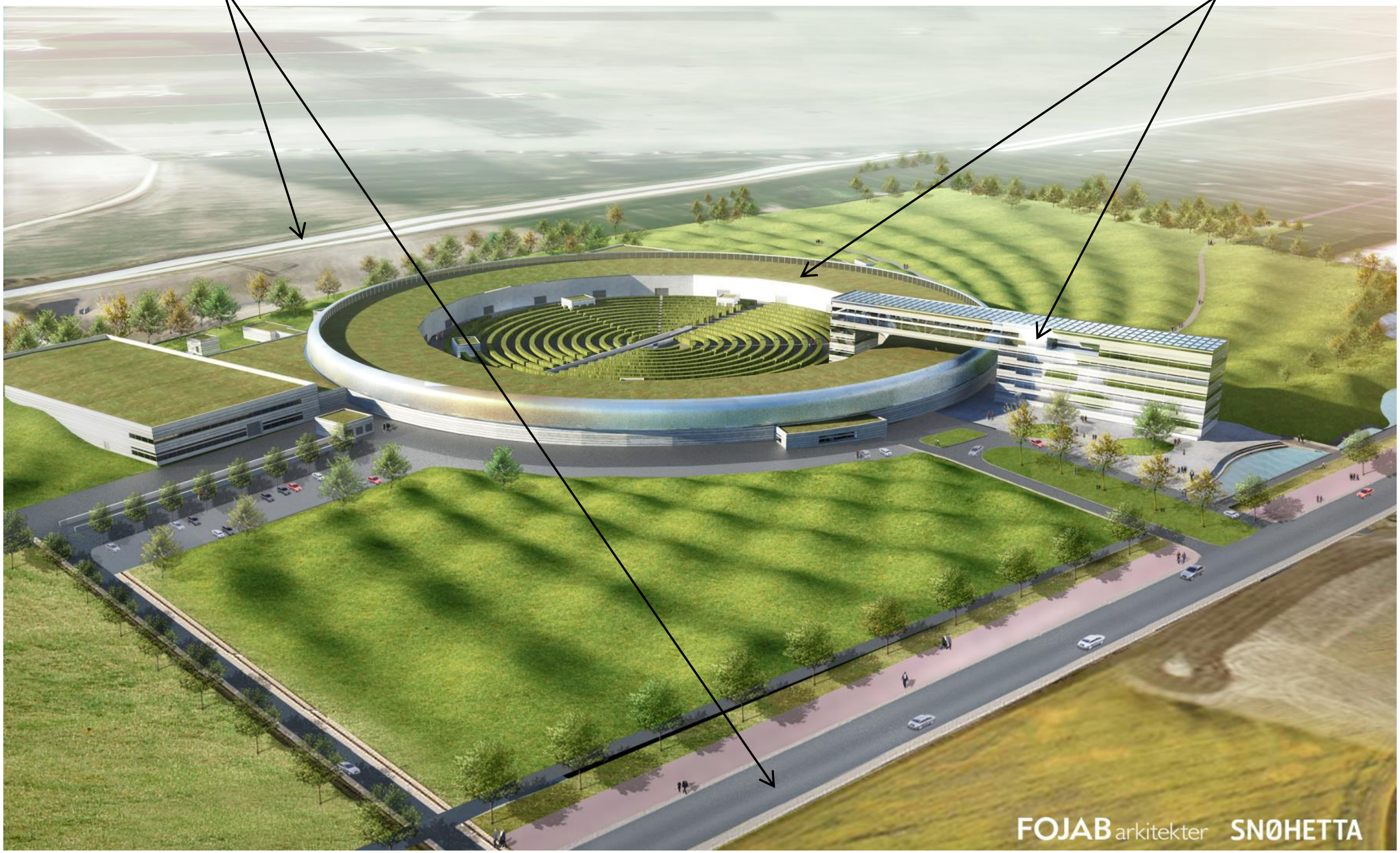
Aurora:
- 200 nodes
- 20 CPU cores/node
- 64 GB ram/node
- and, GPU nodes

MAX IV

- Synchrotron light source

External loads

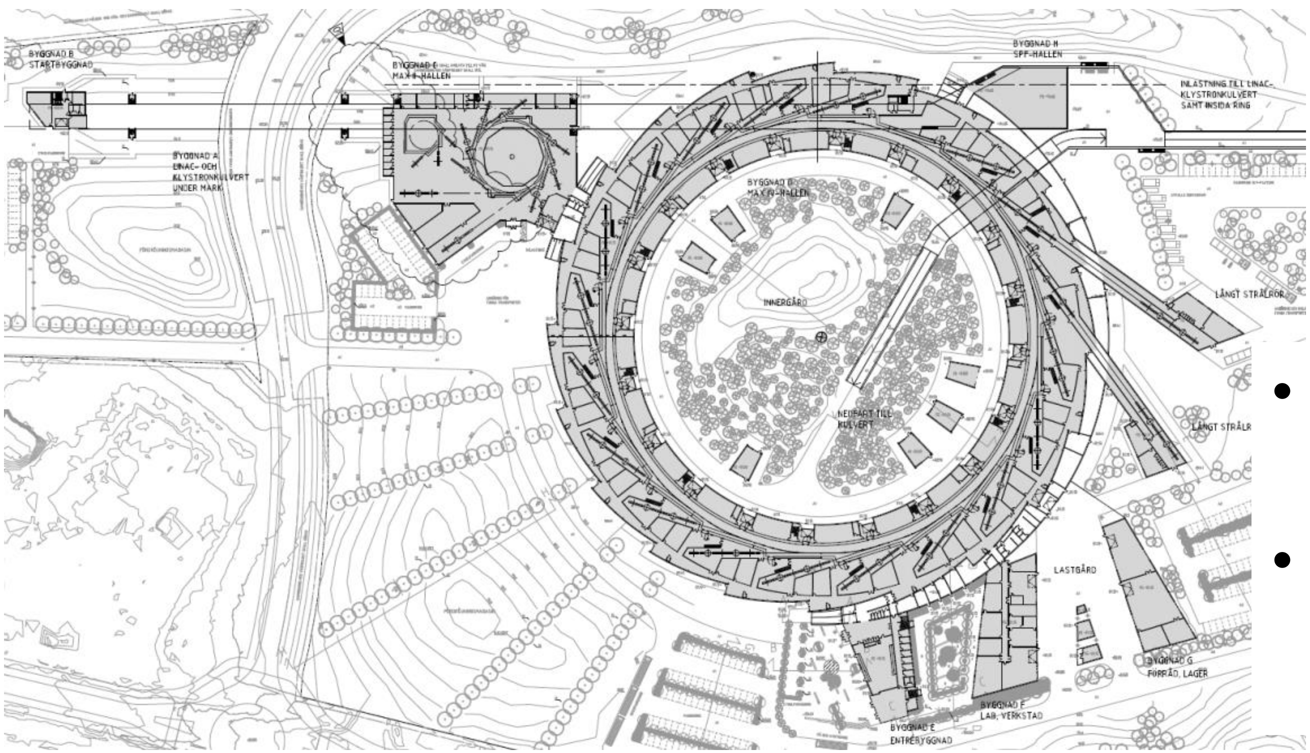
Internal loads



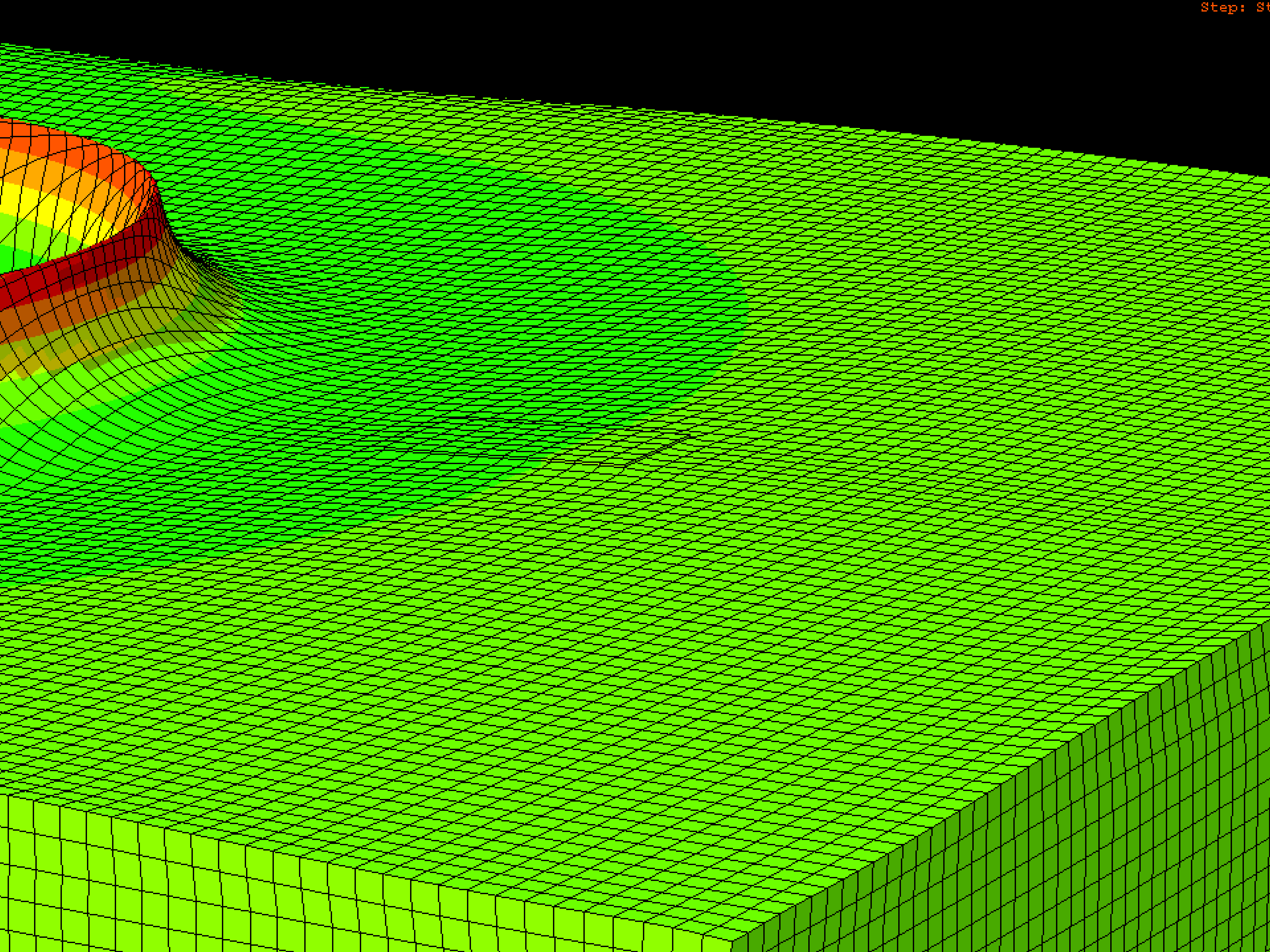
MAX IV

- Synchrotron light source

- Max. vibration RMS 26 nm (26 10^{-9} m), 1s
- Diameter of human hair, ~75 μm (75 10^{-6} m)
- 3000 times

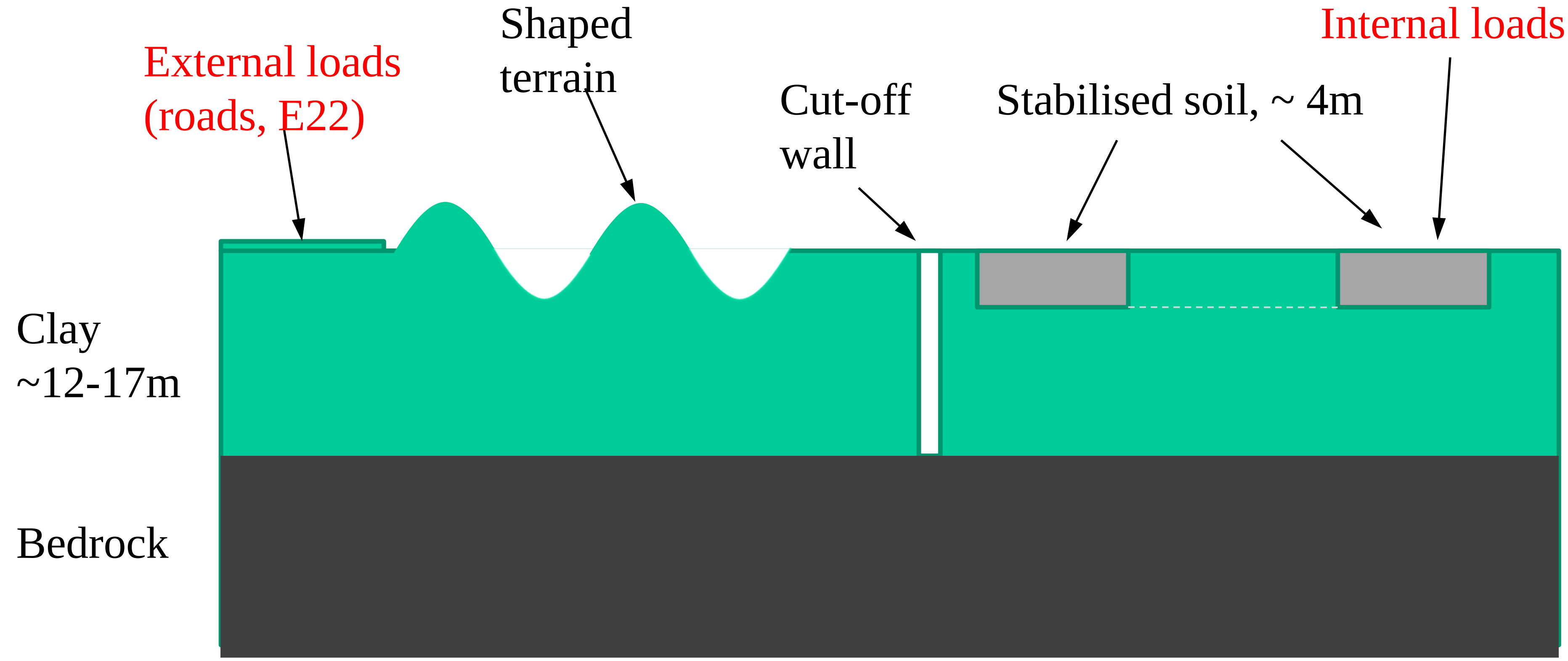


- Linear accelerator ~ 500m
- Storage ring Perimeter ~700m


Step: St

MAX IV - investigation of vibration reducing measures

Peter Persson and Kent Persson



Some results of measures

- Soil stabilisation
  - Reduction of vibrations from external loading ca 25%.
  - Reduction of vibrations from internal lloading ca 50%.

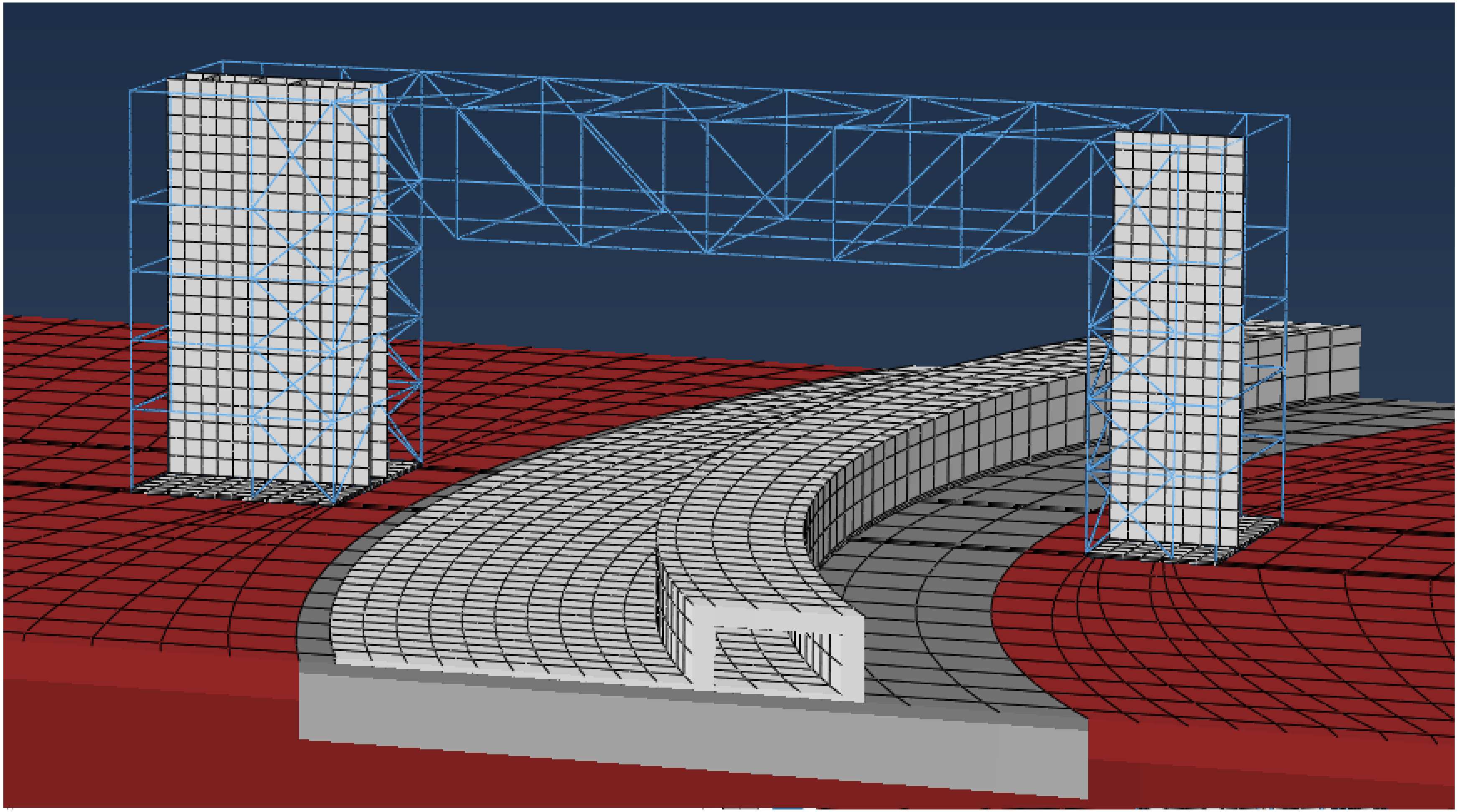
- Cut-off wall
  - Reduction of vibrations from external loading up to ca 45%.

- Shaped terrain
  - Reduction of vibrations from external loading up to 40%.

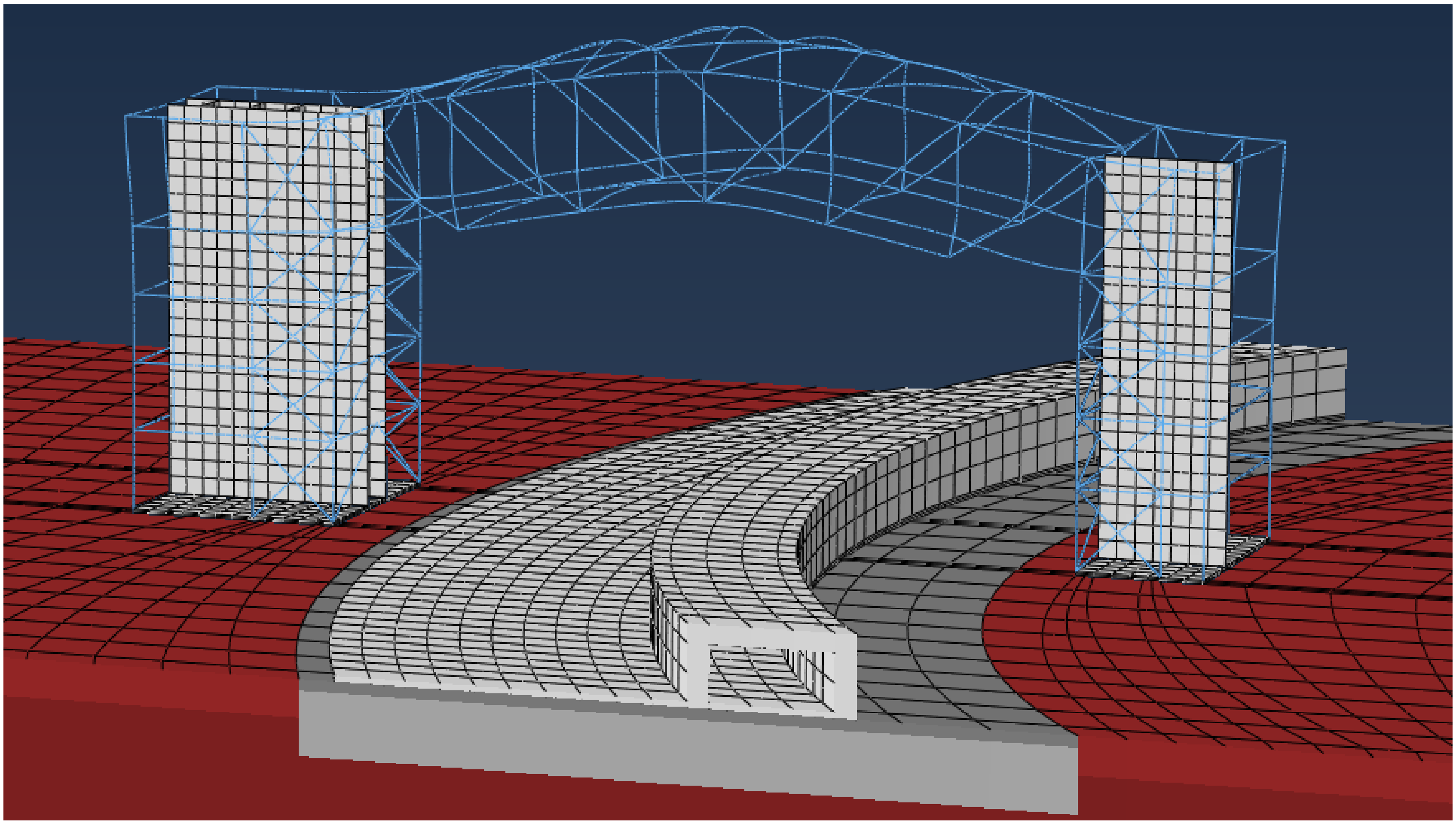
    (Need long distance between source and building)

MAX IV
– vibrations from office building

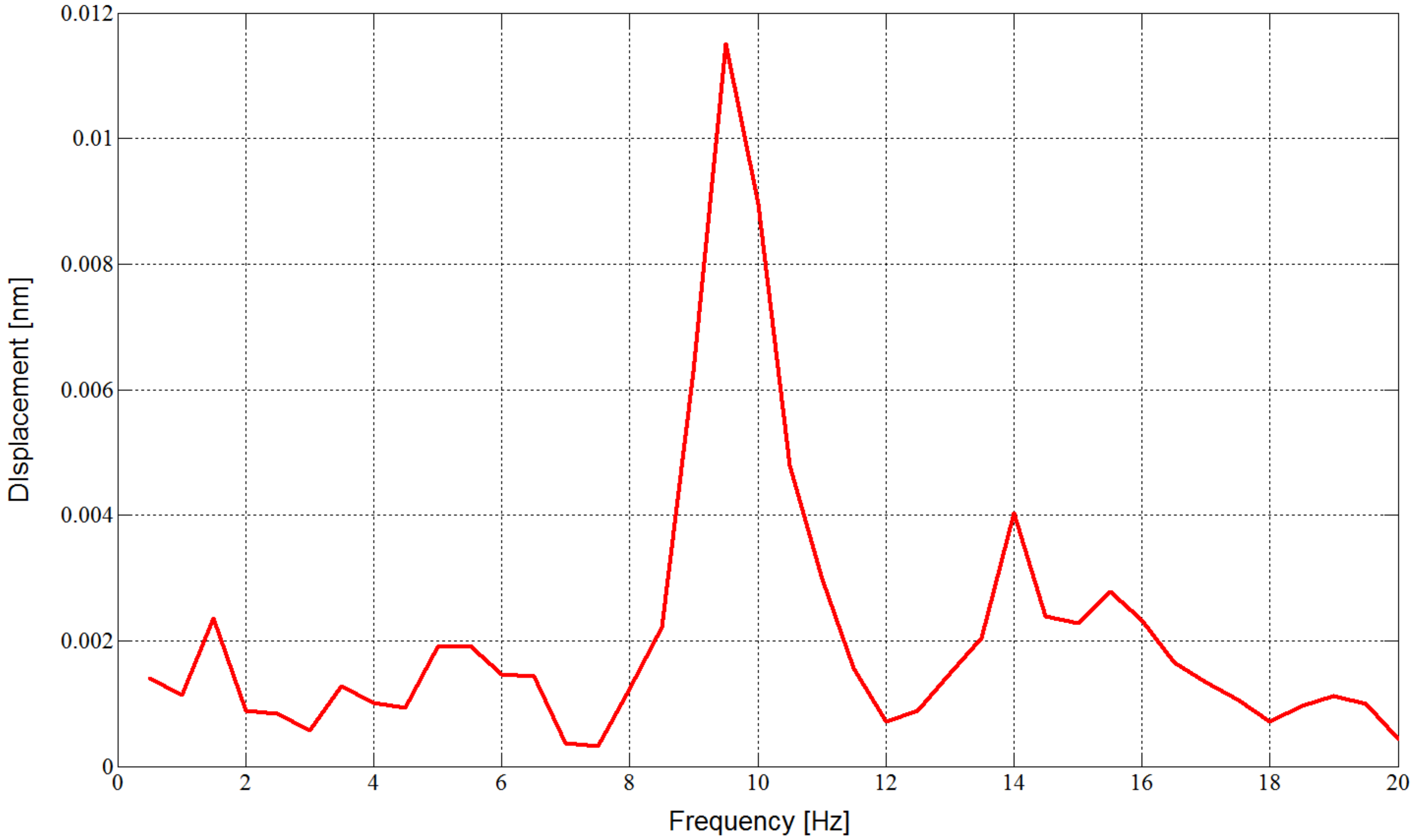
Ola Flodén and Kent Persson



MAX IV
– vibrations from office building



MAX IV
– example vibrations from office building

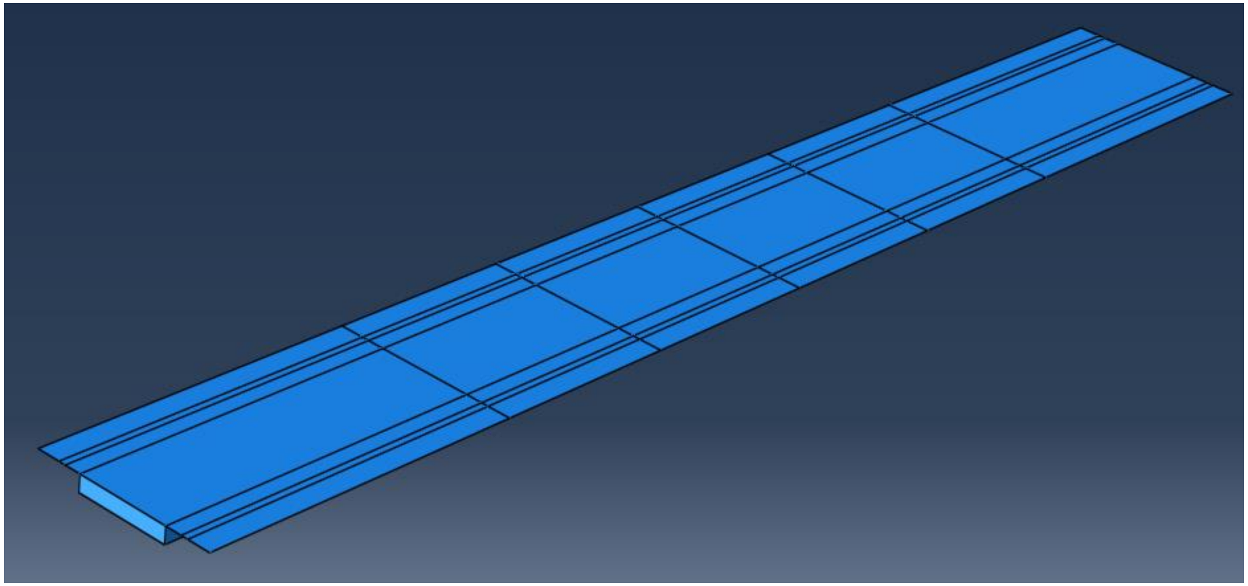


Assignment 2

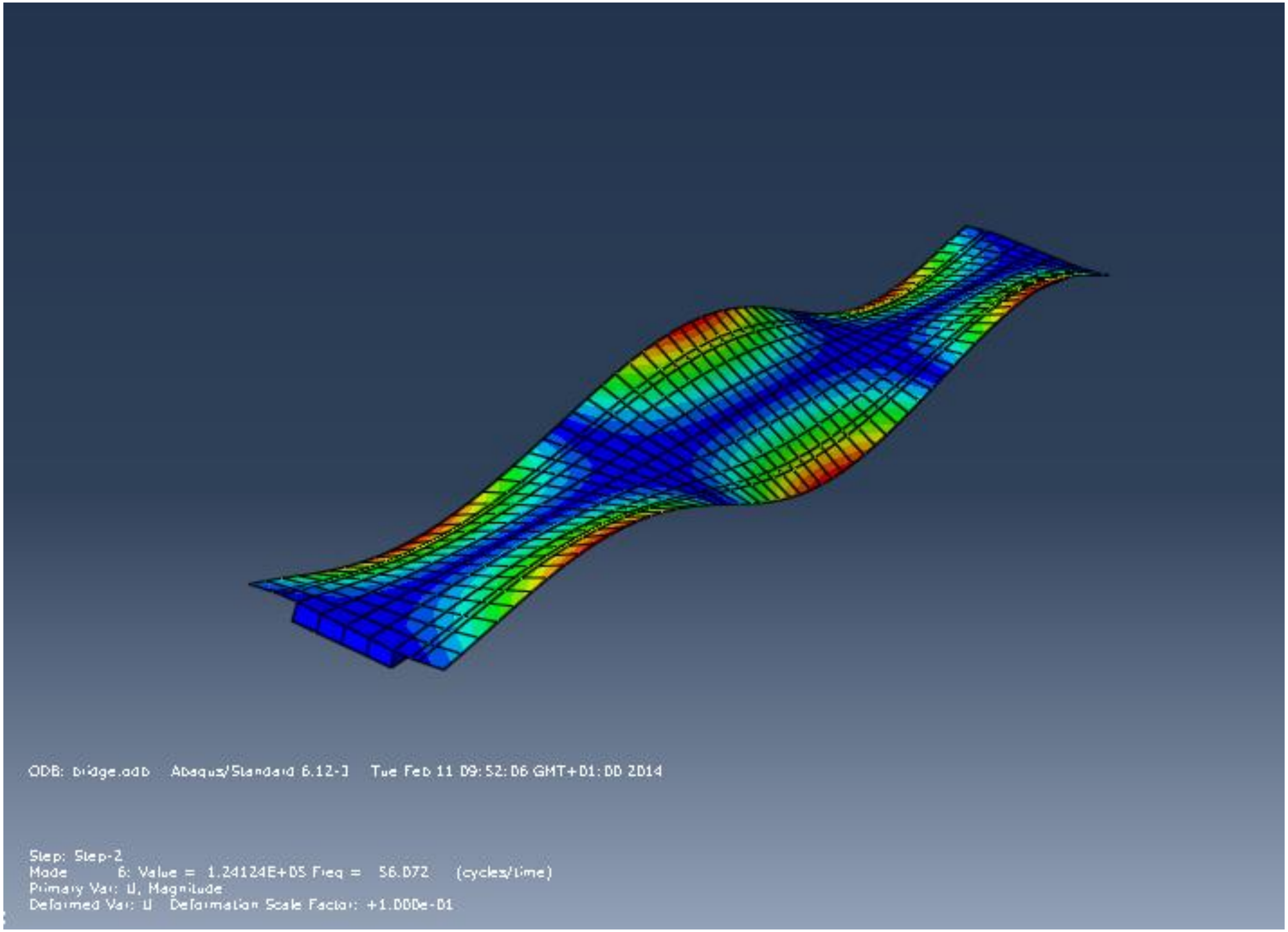
Tacoma Narrows Bridge

Assignment
Dynamic analysis of a bridge

- Calculate eigenvalues and eigenmodes
- Calculate response for impulse load (transient)
- Determine the number of modes needed for the impulse load (modal reduction)



Eigenmodes


ODB: bridge.odb Abaqus/Standard 6.12-3 Tue Feb 11 09:52:06 GMT+01:00 2014
Step: Step-2
Mode 6: Value = 1.24124E+05 Freq = 56.072 (cycles/time)
Primary Var: U, Magnitude
Deformed Var: U Deformation Scale Factor: +1.000e-01

ABAQUS-tutorials

- Tutorials on the course homepage:
  - Tutorial 1-3 modelling of static analyses
  - Tutorial 4 modelling of different types of dynamic analyses