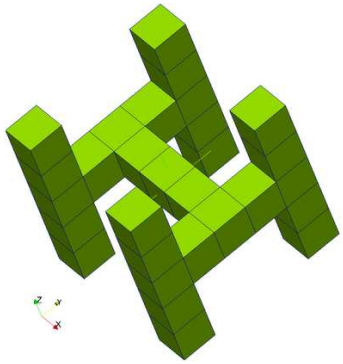
Exercise

BIOMECHANICAL MODELLING OF BONE AND CARTILAGE, April 2009

Given:

Artificial cubical trabecular bone biopsy as shown in the figure below.



The geometry as well as the face node sets are provided as Abaqus/Calculix input file using:

Voxel length x,y,z	0.1, 0.1, 0.1 mm
Voxel number x,y,z	5, 5, 5

The node sets are indicated with W ($x = 0$), E ($x = L$), S ($y = 0$), N ($y = L$), B ($z = 0$), T ($z = L$) where W, E, S, N, B, T means West, East, South, North, Bottom, Top face. The bone finite element consist of bone tissue with the following material constants:

E_{Tissue}	ν
20000 MPa	0.3

Tasks:

Perform a virtual confined compression test using FEM (ABAQUS or CalculiX) and determine the homogenized material constants E_x, E_y, E_z.

Each Student has to do the follow subtasks:

- take the given mesh file and add the material as well the required 3 step definitions

- analyse 3 load steps in the x, y, z direction where you fix one end and pull on the other end. For example a loading in z-direction look like: Node set B $u_x = u_y = u_z = 0$ and node set T $u_z = -0.1$ (remaining DOFs are free)
- generate an Abaqus/CalculiX input file
- analyze your model with Abaqus/CalculiX
- produce some deformation and stress plots (von Mises stresses)
- determine the virtual tested confined compression parameters E_x, E_y, E_z by using the formula e.g shown for loading in z-direction:

$$F_{\text{avg},z} = \frac{E_z\, A}{L} u_z$$

  where u_z is the applied displacement (e.g. on T), $F_{\text{avg},z}$ is the average forces (e.g. on T), A is the cross section, L is the length (e.g. along z), and E_z is the unknown quantity. In order to get $F_{\text{avg},z}$ simply write out the reaction forces to a text file (*.dat) and average them by hand.
- summarize your results in a short report (sections: introduction, methods, results, discussions) including some fringe plots as well as the major results.