Comparison of tetrahedral and different hexahedral GMSH mesh in Abaqus

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1 Mesh configuration

For the comparison of different meshes, two meshes have been created, one with tetrahedrons and one with hexahedrons. Both should roughly have the same amount of elements. The geometry is a squared block with length $l = 1000\ mm$ with a spherical inclusion with radius $r = 300\ mm$ on the origin. The following options has been used to generate the tetrahedral and hexahedral mesh:

option	tetrahedral	hexahedral
mesh algo.	Delaunay	frontal-Delaunay for Quads
mesh algo. 3D	Delaunay	Delaunay
subdivision algo.	none	all hexahedra
recombination algo.	blossom	blossom

2 Simulation configuration

The simulation case is fixing one surface completely and the opposite surface in two directions, the load, is configured by displacing the opposite surface by 100 mm downwards.
The following configuration has been chosen:

- $-x-$Surface is fixed in all directions and motions.
- $+x-$Surface is fixed in $x-$ and $z-$direction
- $+x-$Surface is displaced in negative $y-$direction with a value of 100 mm

Apart from that, the materials in the box as well as in the inclusion are the same.

3 Results

3.1 Difference between tet and hex mesh

The load case results in the following deformation (see figure 1). In figures 2, 3 and 4 the stress results are compared:

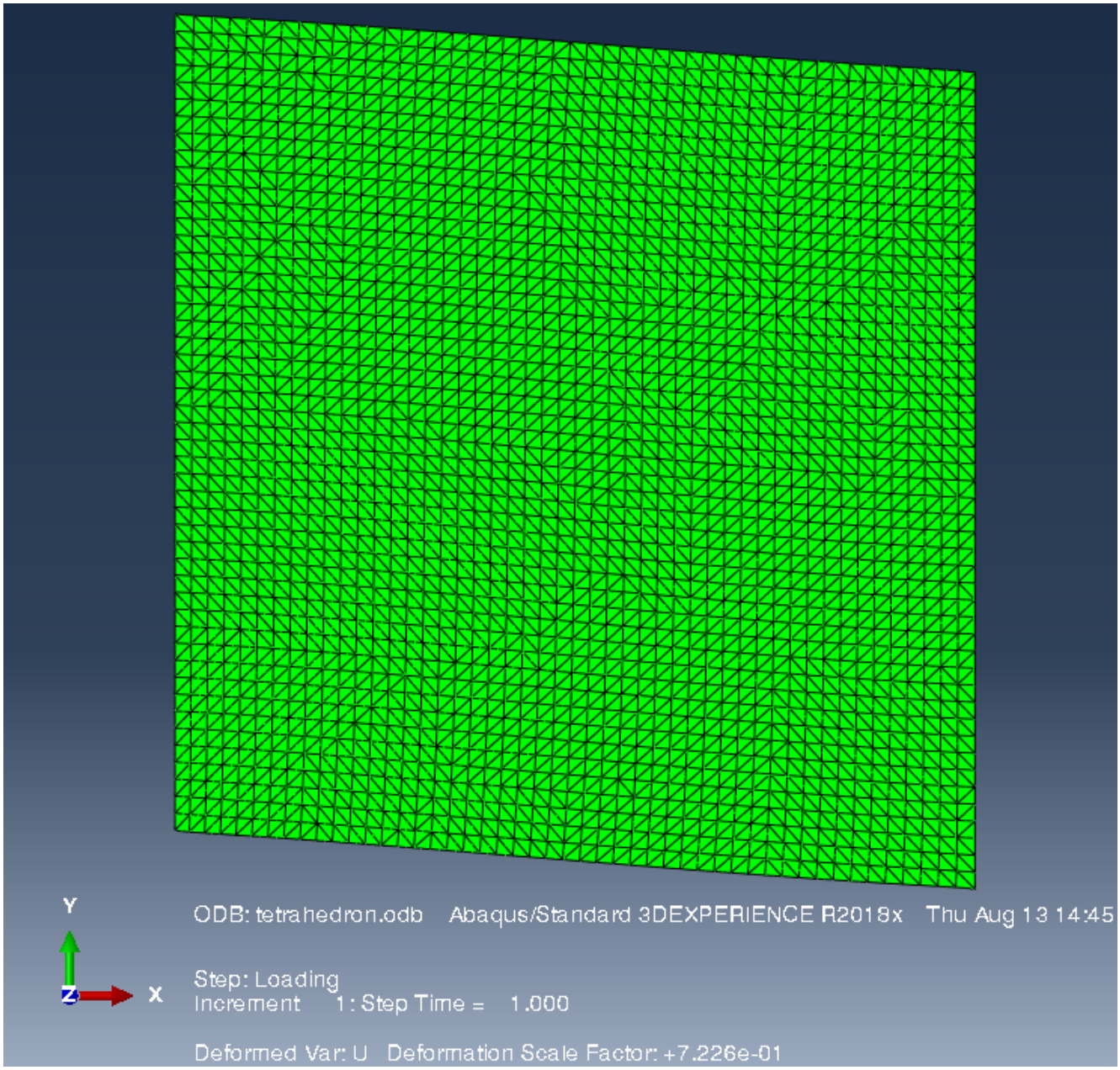
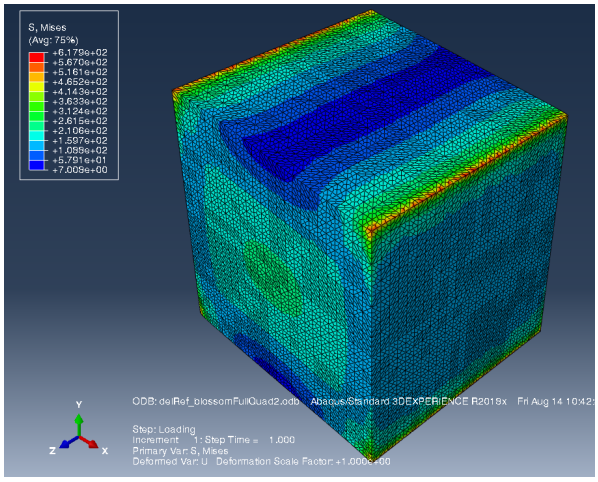
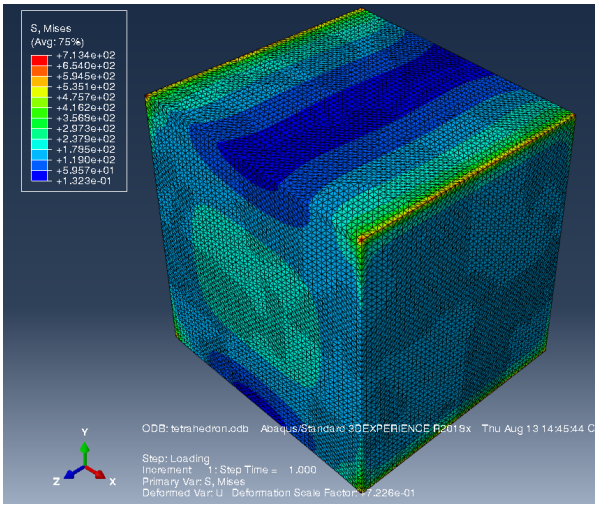


Figure 1: Deformation of the body in the x-y-plane

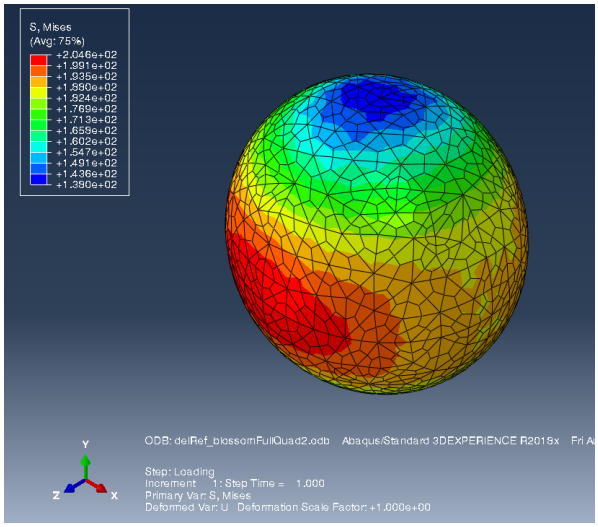


(a) Hexahedral mesh of RVE

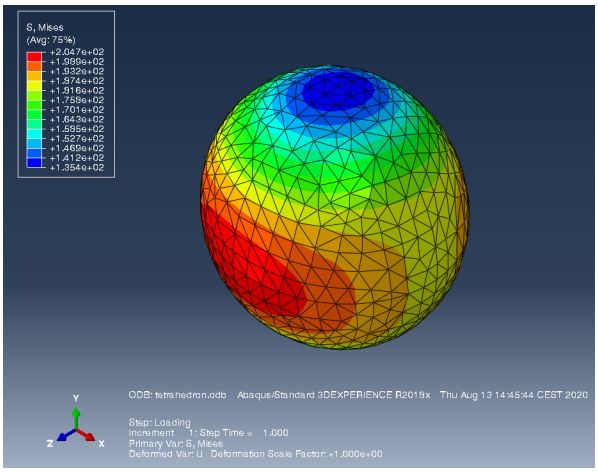


(b) Tetrahedral mesh of RVE

Figure 2: Stress result on RVE

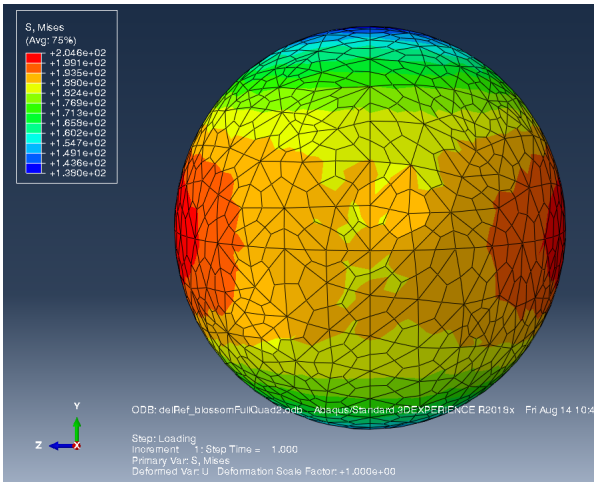


(a) Hexahedral mesh of RVE

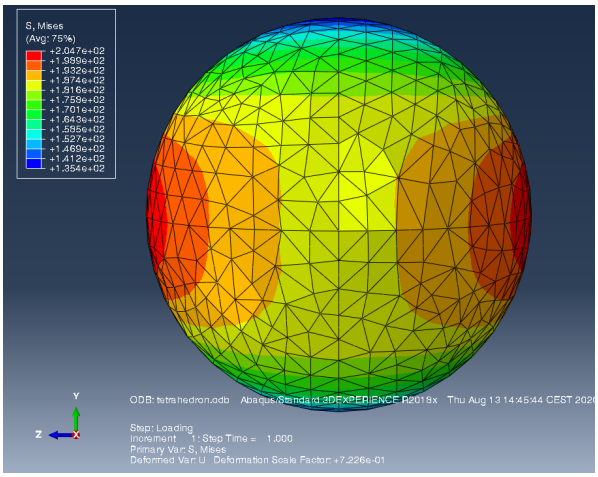


(b) Tetrahedral mesh of RVE

Figure 3: Stress result on inclusion



(a) Hexahedral mesh of inclusion



(b) Tetrahedral mesh of inclusion

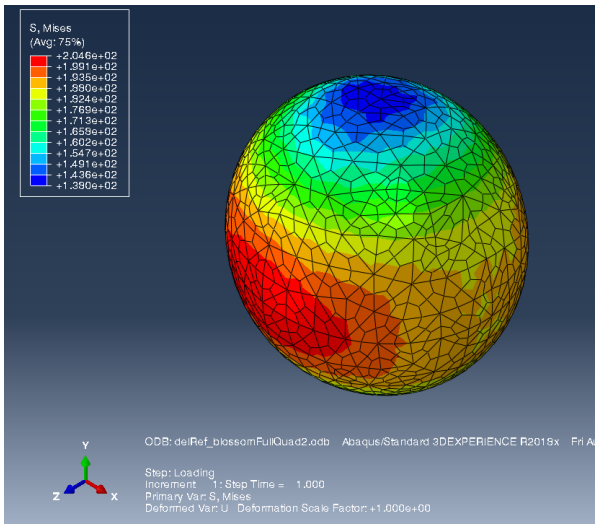
Figure 4: Critical view of inclusion

3.2 Comparison of different mesh sizes for hex meshes

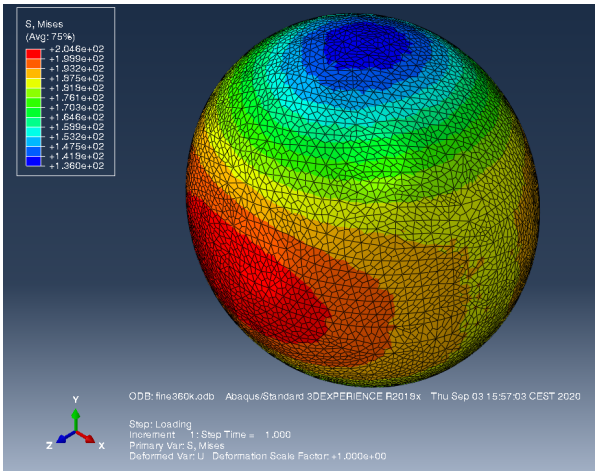
The load case for the finer mesh is the same as above for the tetrahedral and the coarse hexahedral mesh. In table 1 the difference of the hex meshes are contrasted, where in the figures 5, 6 and 7 the results are compared:

	coarse	fine	very fine
# el. on RVE boundary	48	48	48
# el. on sphere circumference	80	160	360
total # el.	120.000	360.000	1.261.000

Table 1: Configuration of the hex meshes

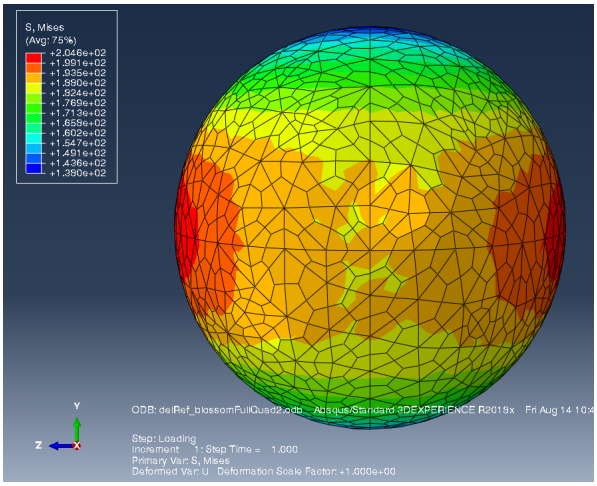


(a) coarse hexahedral mesh of RVE

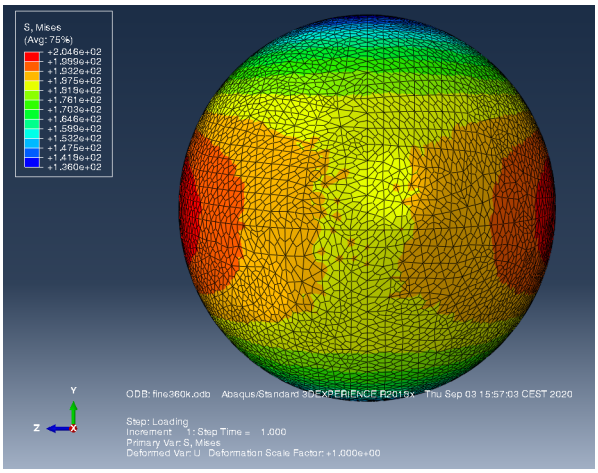


(b) fine hexahedral mesh of RVE

Figure 5: Stress result on RVE



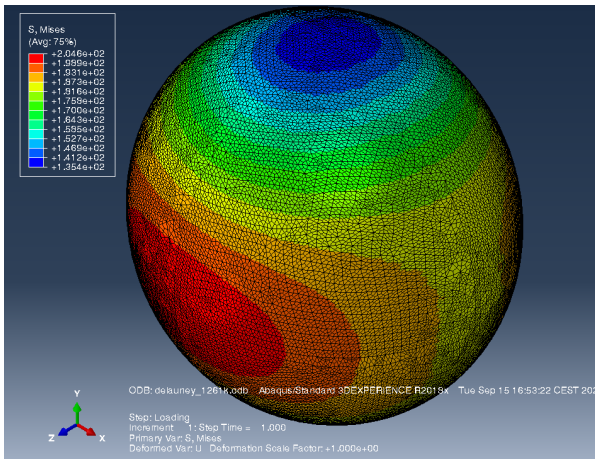
(a) coarse hexahedral mesh of RVE



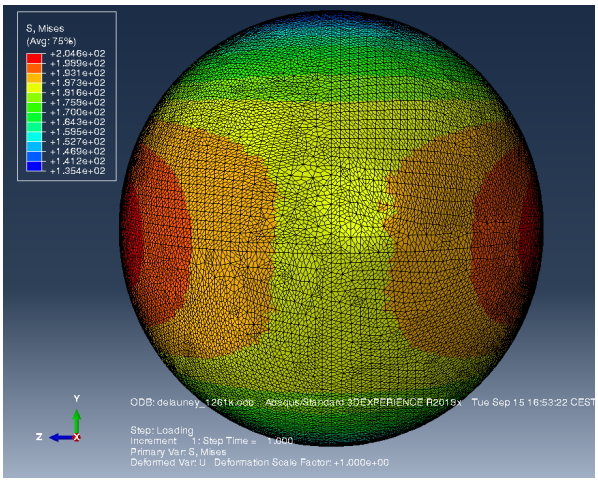
(b) fine hexahedral mesh of RVE

Figure 6: Critical view of inclusion

Next we refined the elements on the inclusion even further (320 elements on the circumference of the circular inclusion), such that we had in the end around 1.261.000 elements. In figure 7 the results are printed. Figure 8 also shows only the contour plot without the element lines.

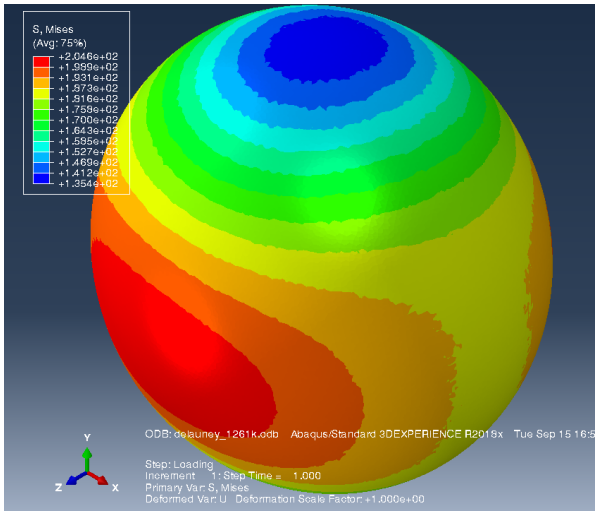


(a) very fine hexahedral mesh of RVE

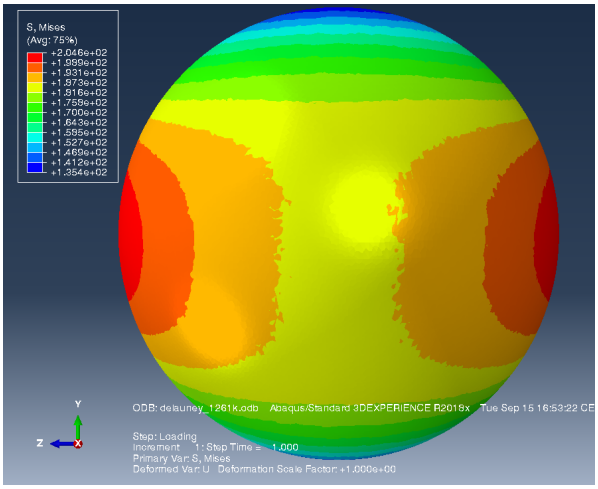


(b) critical view of very fine hexahedral mesh of RVE

Figure 7: Results of the very fine mesh



(a) very fine hexahedral mesh of RVE



(b) critical view of very fine hexahedral mesh of RVE

Figure 8: Contour results of the very fine mesh without the element lines