Problem 2 – Principles of Mesh using ABAQUS Software

Part A) The virtual domain & Modelling Parameters

The virtual domain was created in SolidWorks, the images below show the virtual domain that was then imported into the ABAQUS Software alongside the dimensions of the specimen.

The screenshots also show assignment of the material properties based on the information provided in the brief

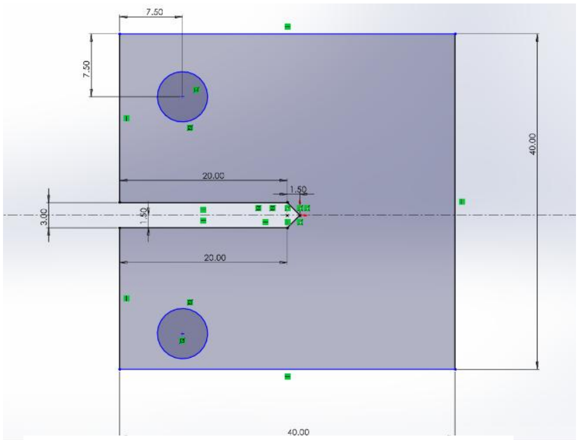

Figure 2.01: Sketch View of Test Specimen

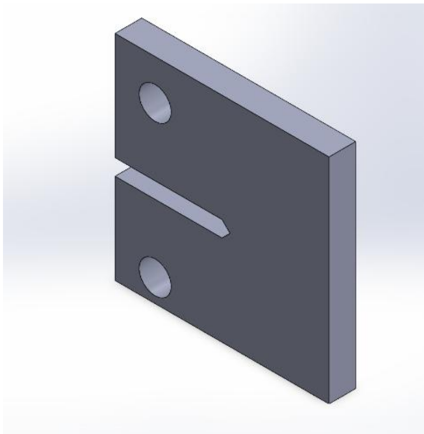

Figure 2.02: Isometric View of Test Specimen

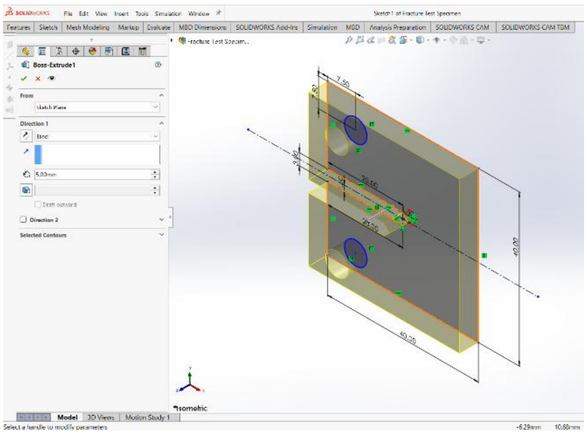

Figure 2.03: Isometric View of Test Specimen (depth)

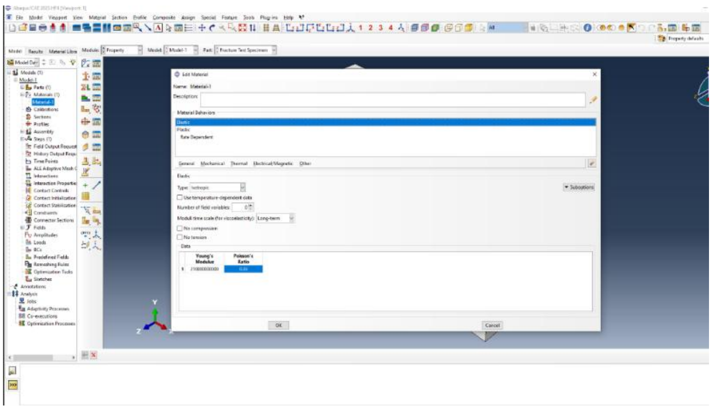

Figure 2.04a: Material Properties

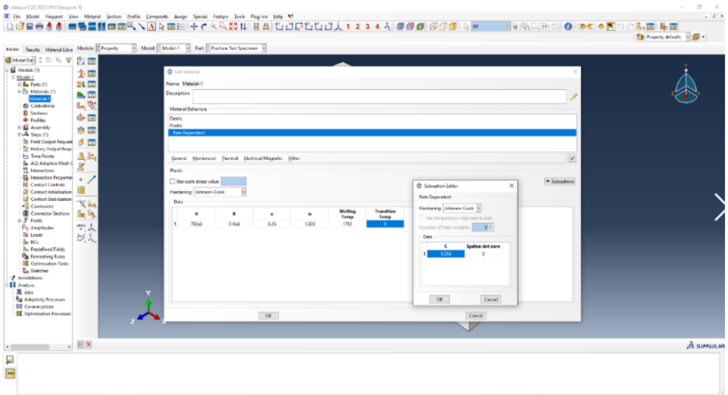

Figure 2.04b: Material Properties

Part B) Mesh Cases

1. Hexahedral Elements

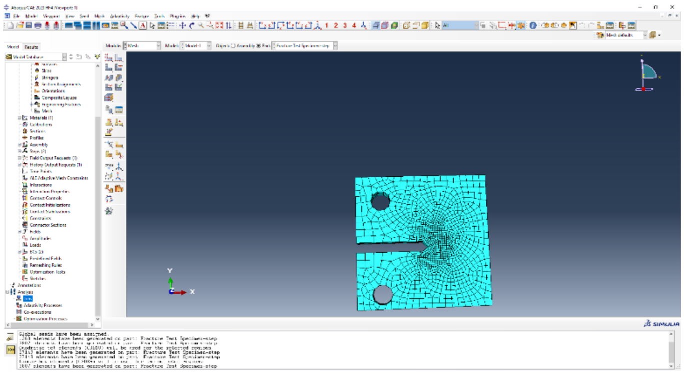

Figure 2.05: Finer hex mesh around crack tip

Figure 5 above shows how having a finer mesh around the crack tip by reducing the element size and increasing mesh density allows for larger number of elements. The number rose from approximately 860 when there was no finer mesh around the crack tip (shown in figure 7 below) to over approximately 3800 (figure 6). The downside of hex meshes is that they do not fit properly around the circles/holes. However, in this situation the focus is around the crack tip, and as such the simple increase in mesh density through the seeding function suffices.

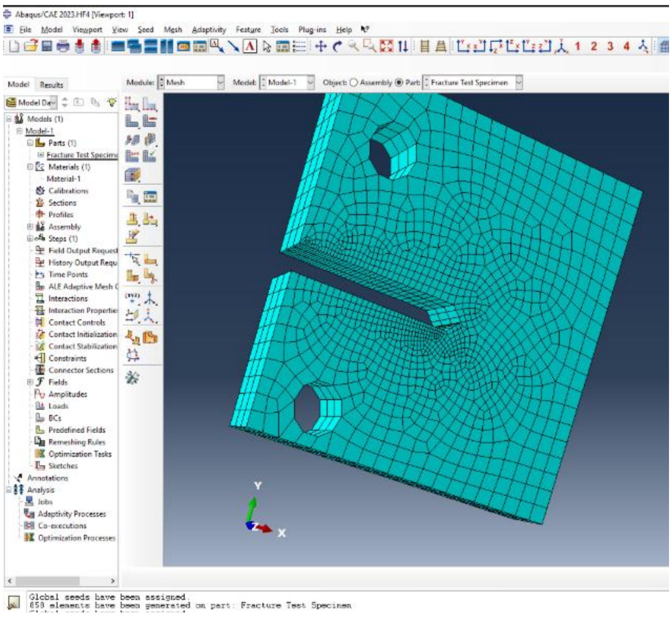

Figure 2.06: Normal mesh(hex)

2. Tetrahedral Elements

Repeating the same process as above but this time changing the mesh element type to tetrahedral elements. In this situation, the element types are triangular and as such fit much better around the circles/holes albeit not a necessary requirement

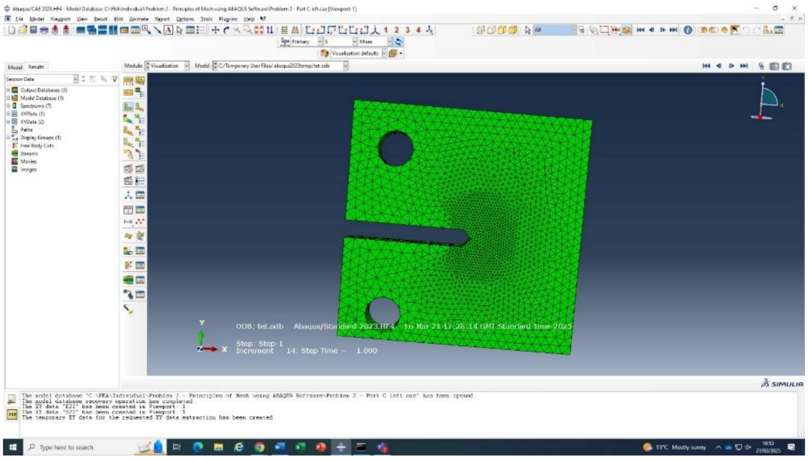

Figure 2.07: Tetrahedral Mesh

3. Wedge Elements

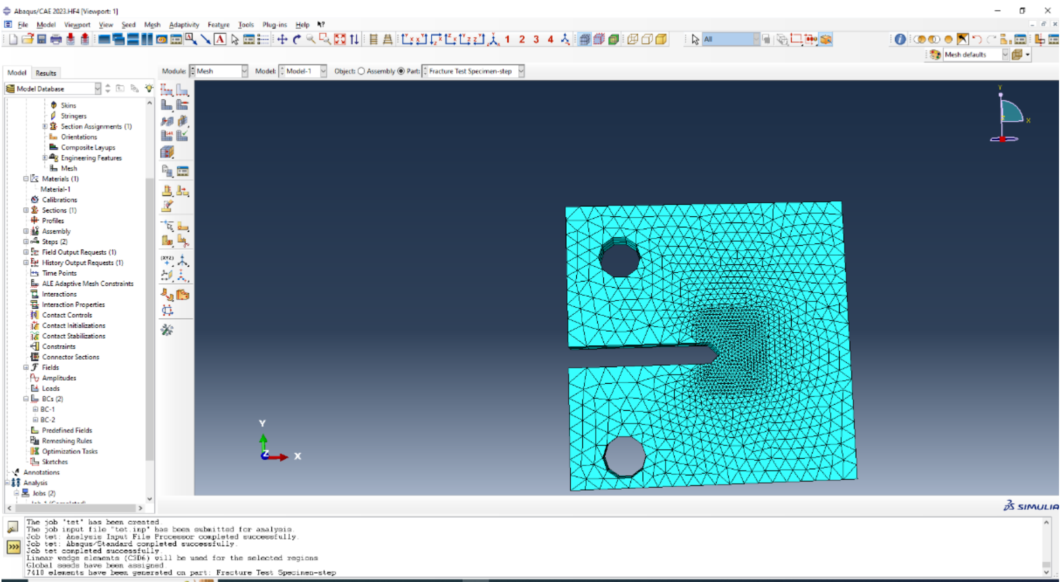

Figure 2.08: Wedge Elements

1. Hexahedral

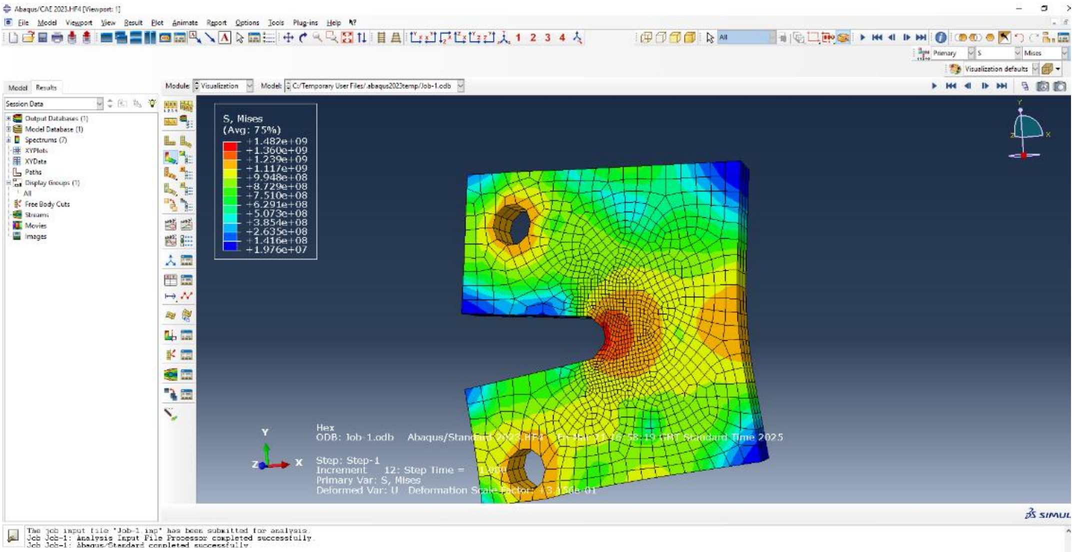

Figure 2.09: Stress Contour Plot (Mises) On the deformed geometry

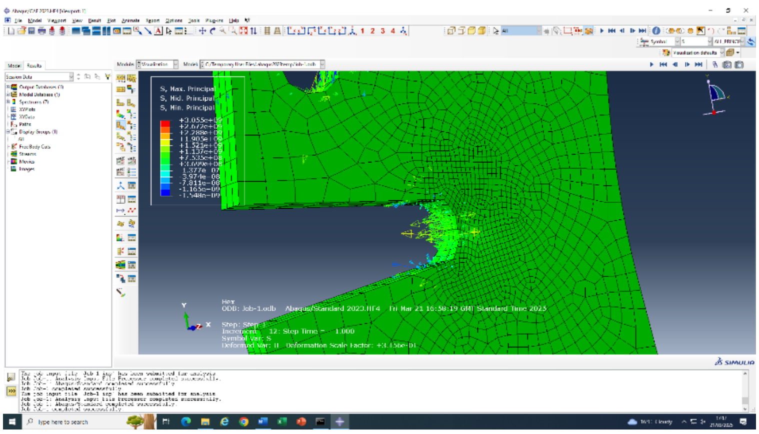
Figure 2.10: Stress Direction (Hex)

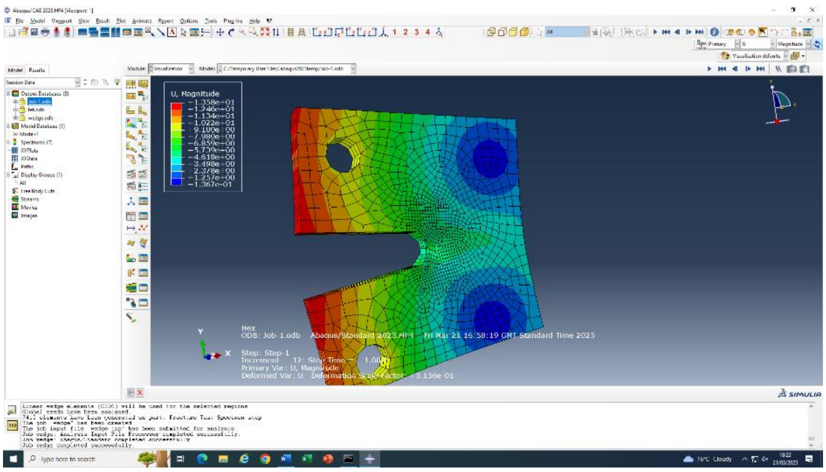
Figure 2.12: Displacement Magnitude (Hex)

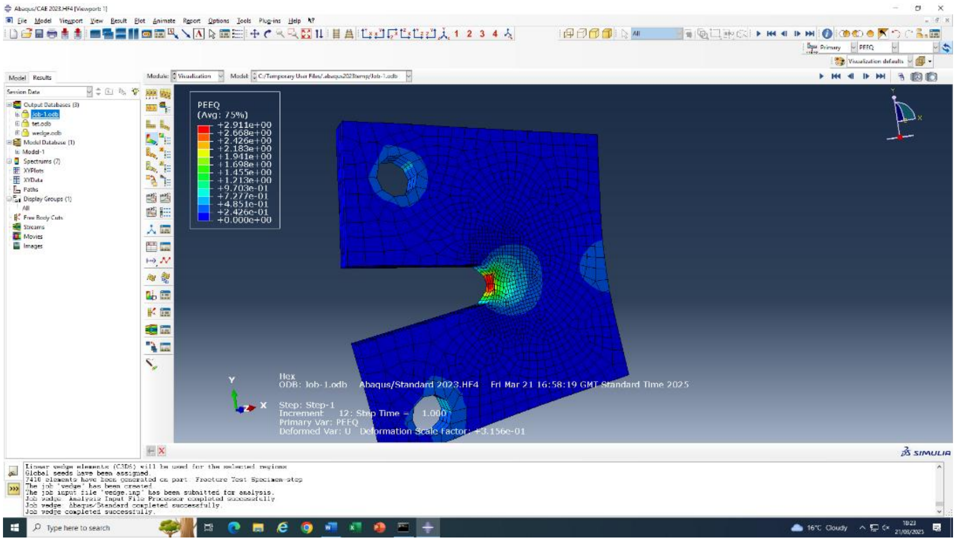

Figure 2.13: PEEQ (Hex)

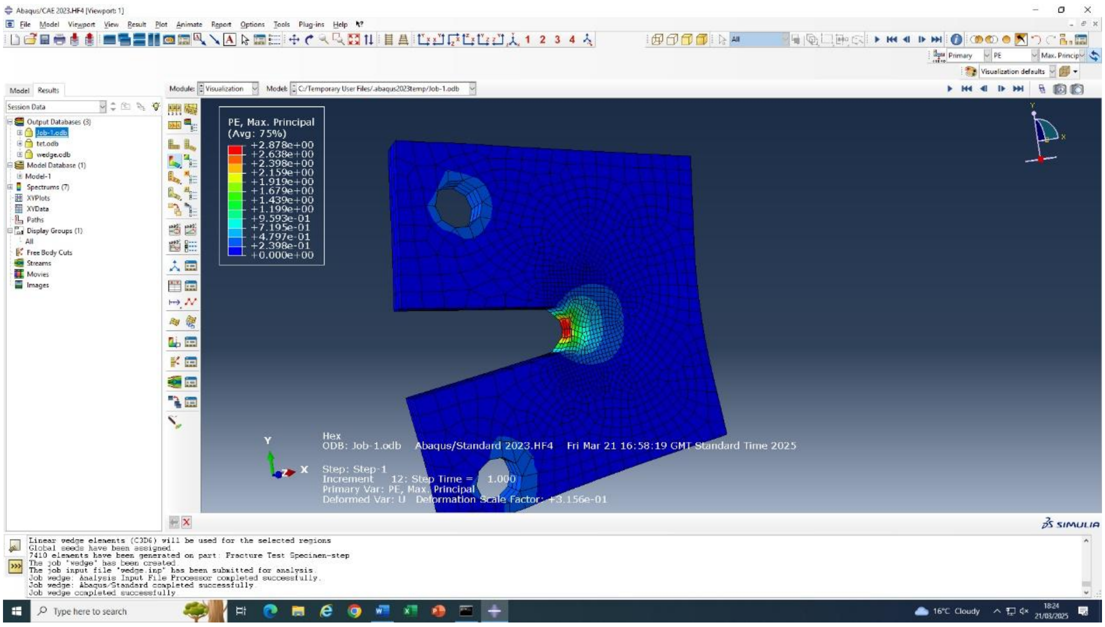

Figure 2.14: Plastic Strain (Hex)

2. Tetrahedral Elements

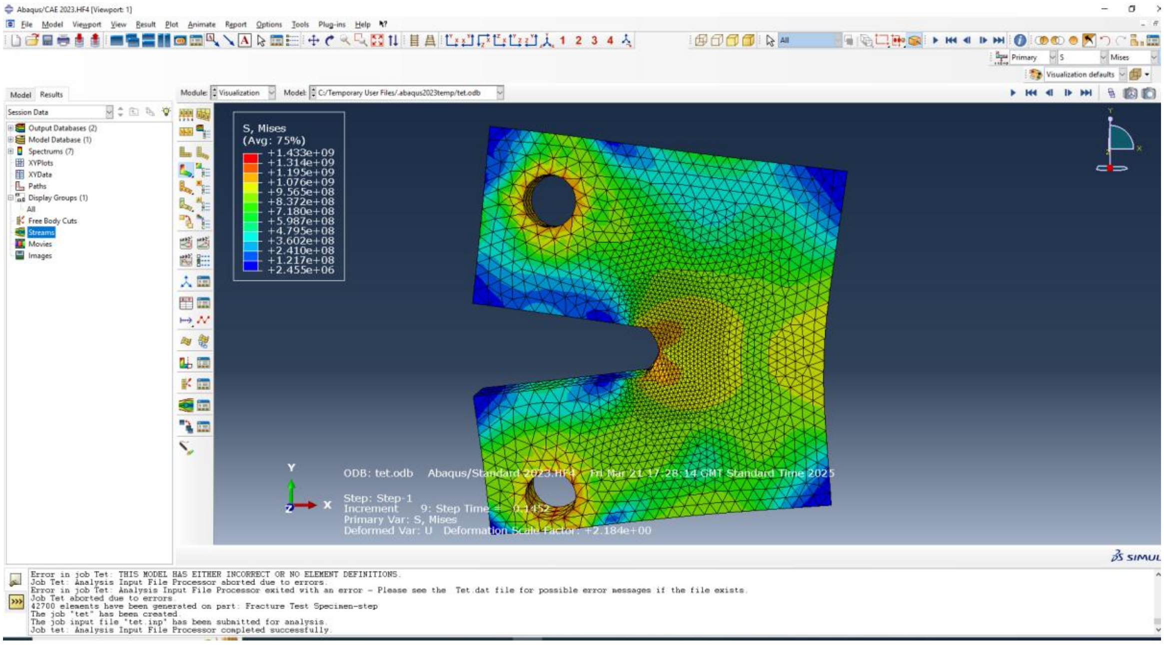

Figure 2.15: Stress Contour Plot (Mises) On the deformed geometry

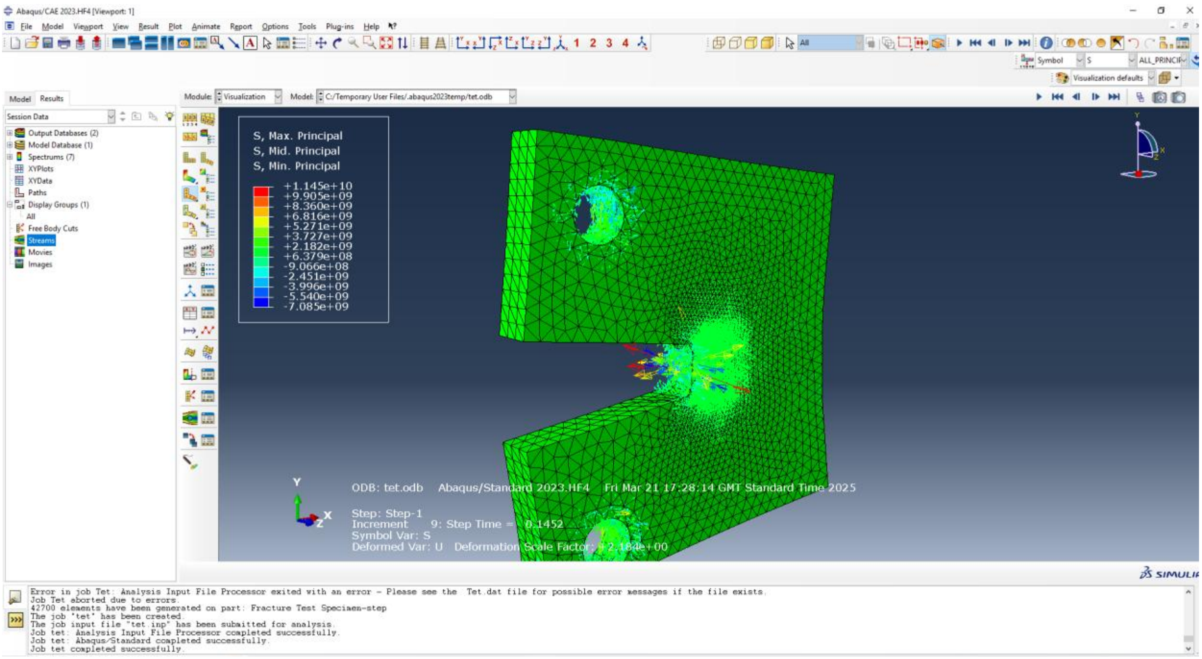

Figure 2.16: Stress Direction plot

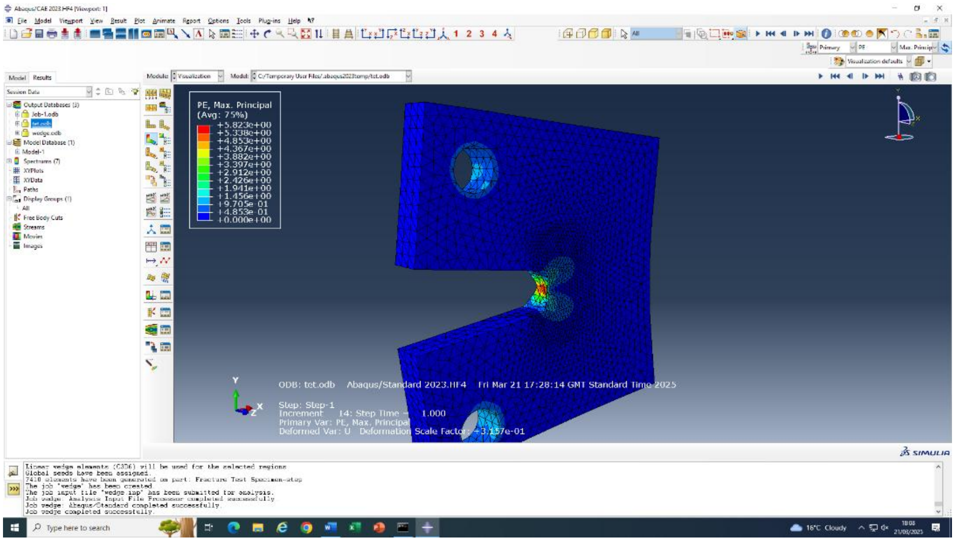

Figure 2.17: Plastic Strain (Tet)

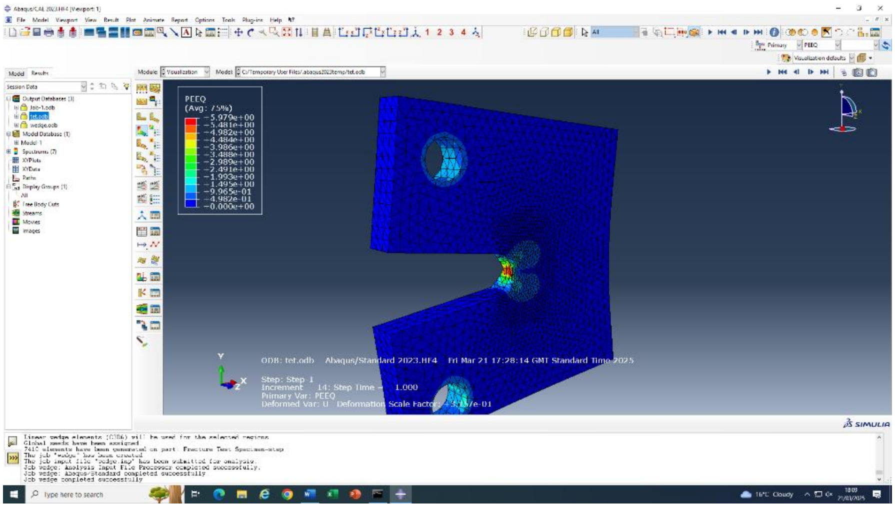

Figure 2.19: Equivalent Plastic Strain (Tet)

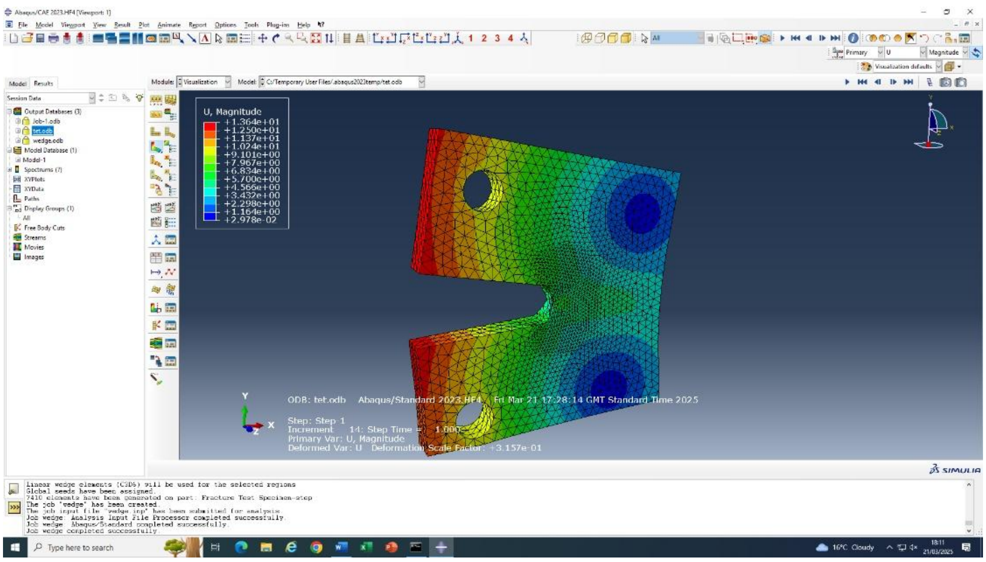

Figure 2.2: Displacement Magnitude (Tet)

3. Wedge Elements

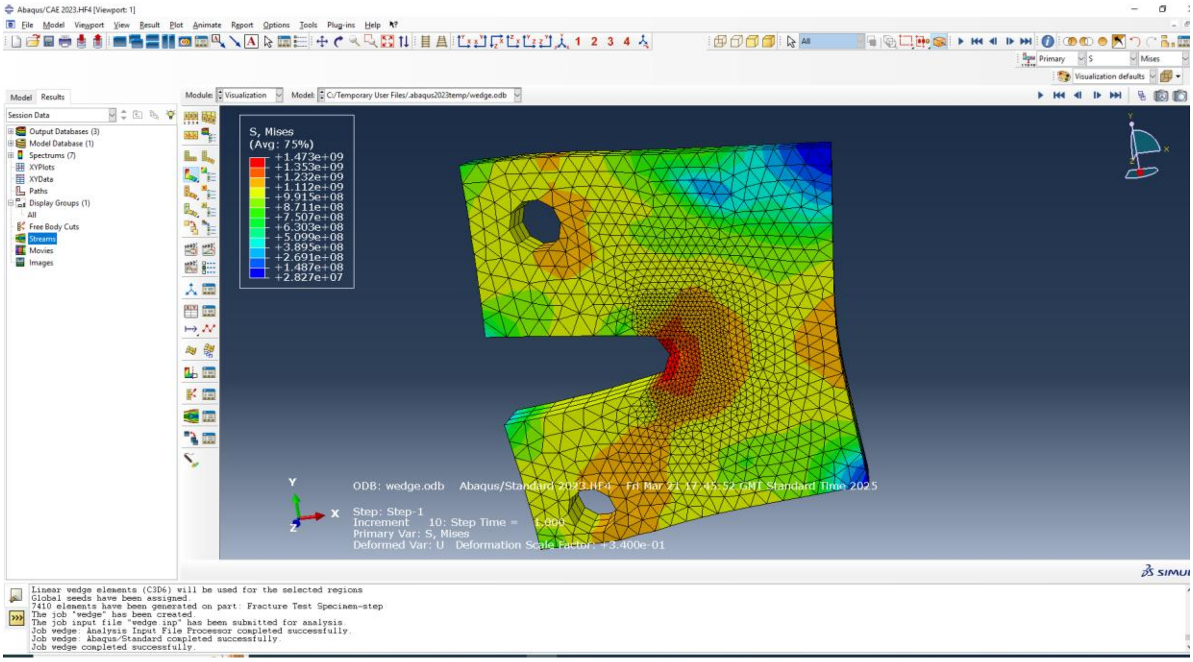

Figure 2.21: Stress Contour plot (Wedge) On the deformed geometry

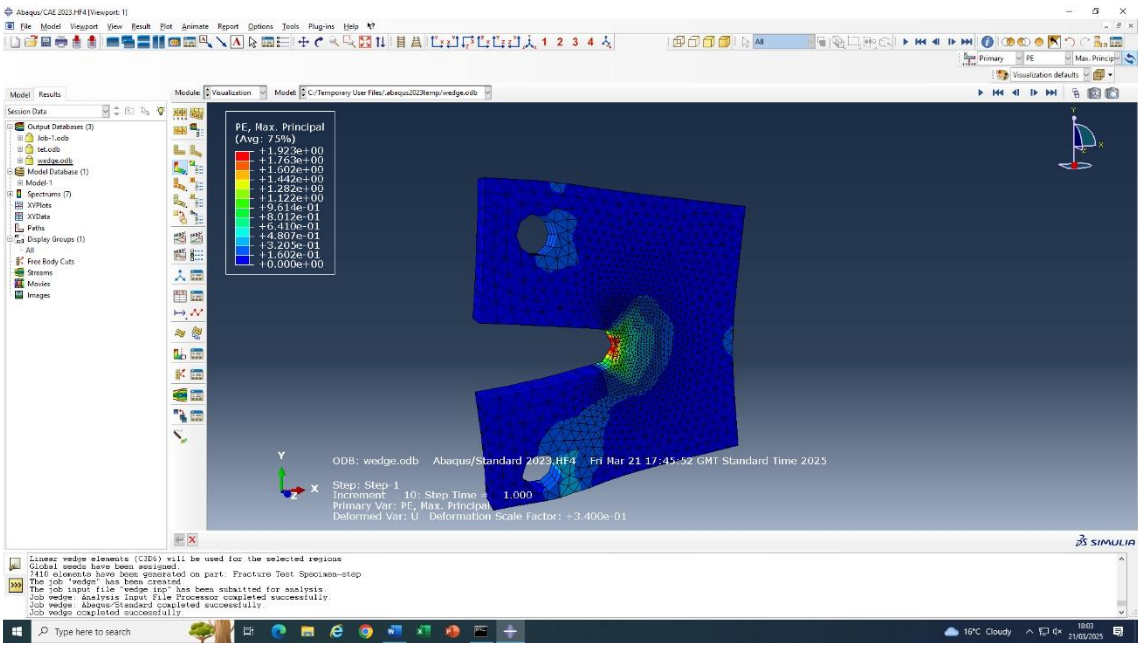

Figure 2.22: Plastic Strain plot(wedge)

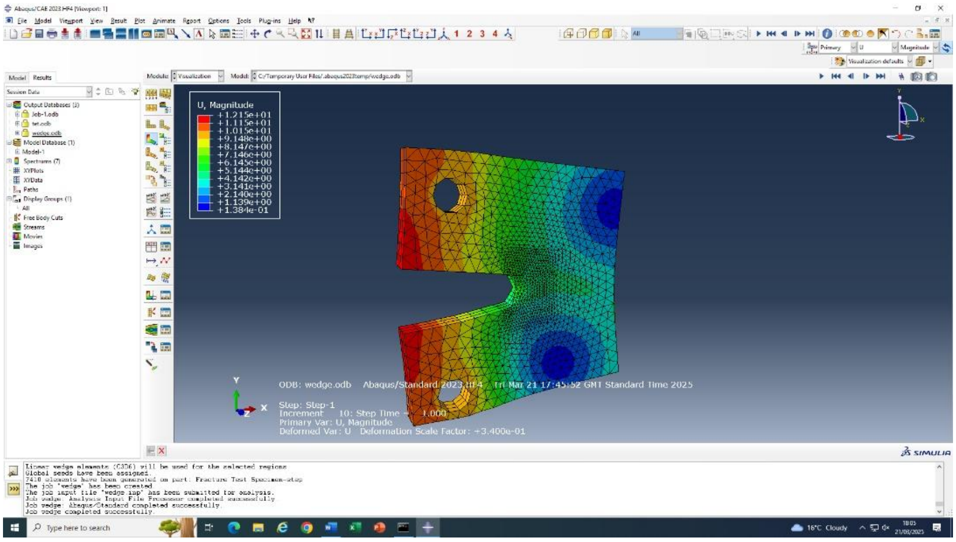

Figure 2.23: Displacement Magnitude (wedge)

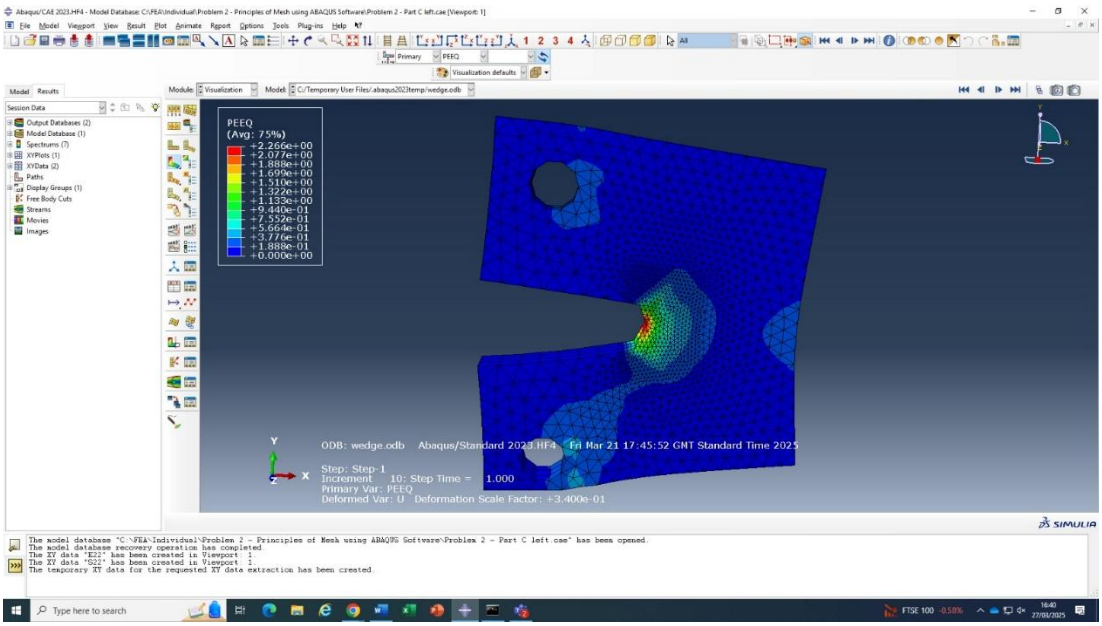

Figure 2.24: PEEQ (wedge)

Part C) Results

Influence of element choice:

The choice between different mesh elements is one of quite significance. By using the stress (mises) plots as a reference (figures 2.09,2.15, 2.21) the accuracy of the results changes. The wedge mesh element had a von mises as high as 1.473×10^9 and the hex mesh element had stress as high as 1.482×10^9 whereas the tetrahedral mesh element recorded 1.433×10^9. Although the actual numerical values are close to each other what is important is the distribution of the elements. Referring to the figures, the elements behaviour around vertices and edges differ, for example near the circles /holes the way elements do not "line up" in the hex mesh elements relative to the tetrahedral mesh elements. This is due to the actual shape of the elements; the triangular element is able to sit on the circumference of the holes whereas the hex elements which are squarer in shape and hence are unable to fit correctly on the circumference of the holes. In terms of choosing one mesh element over another, is topic of discussion and varies from each geometry to the type of loads applied as well. For problem 2, the displacements applied are on the holes, but the actual stress and area of concern is the crack tip, and, in this situation, the tetrahedral and wedge mesh elements are much more suitable. In instances where the load/displacement isn't applied to tips or regions like circles/holes the hex method is potentially better as it reduces the computational load of the simulation (relative to the wedge and Tet elements, the hex element is larger for a given mesh size and as such the less fine and computationally less intensive).

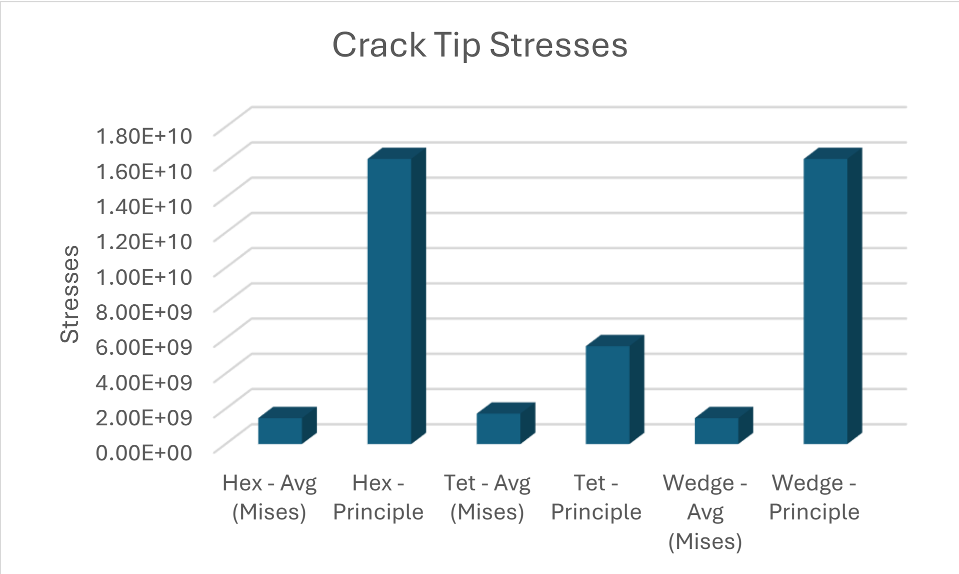

Figure 2.25: Crack Tip Stresses

The graph (figure 2.25) above shows variation in results (principles and average stresses) for different mesh elements and shows that principle is always higher than the average at the crack tip. The variation between the element types of results can be explain by the fact that the accuracy of different elements varies the overall result. Due to the shape of the specimen especially around the crack tip (i.e. it is pointy, not round and can be thought of as a vertex, the tetrahedral element serves as the best choice for that region and is the more accurate result between all three element types.