Problem 4 - Principles of Boundary Conditions using ABAQUS Software

Part A) Virtual Domain + Nodal Set

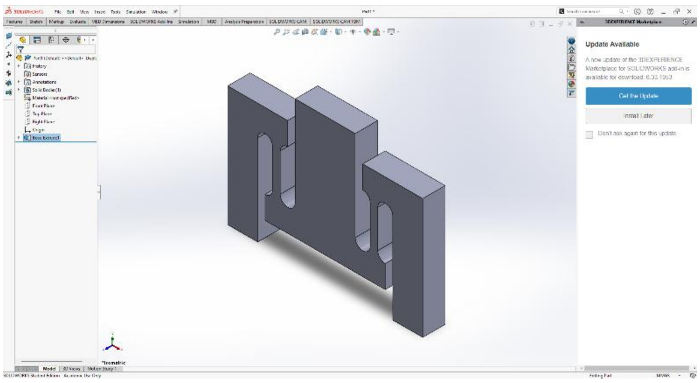

Figure 4.01: SolidWorks Virtual Domain

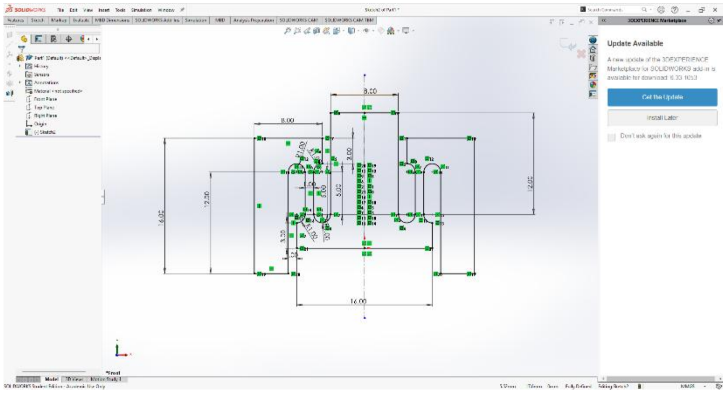

Figure 4.02: Dimensions of Virtual Domain (S.W.)

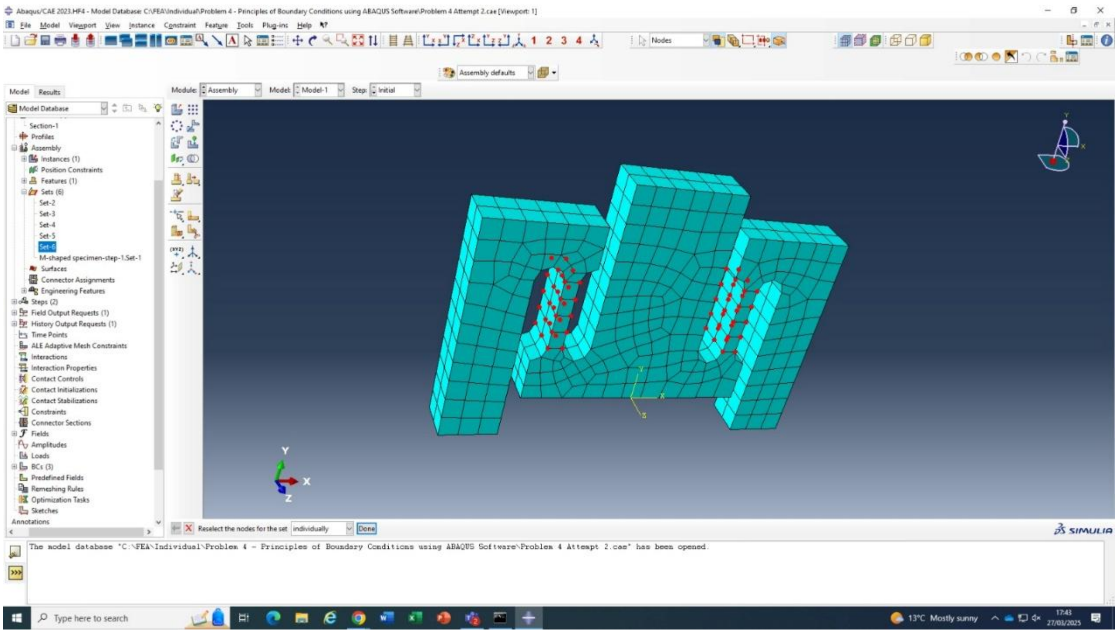

Figure 4.03: Nodal Set on gauge sections

Part B) Test Simulation Results

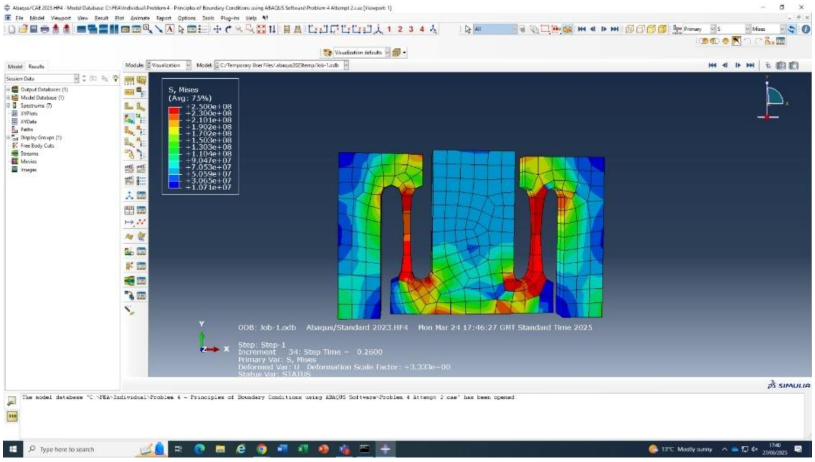

Figure 4.04: Stress Plot (Von Mises)

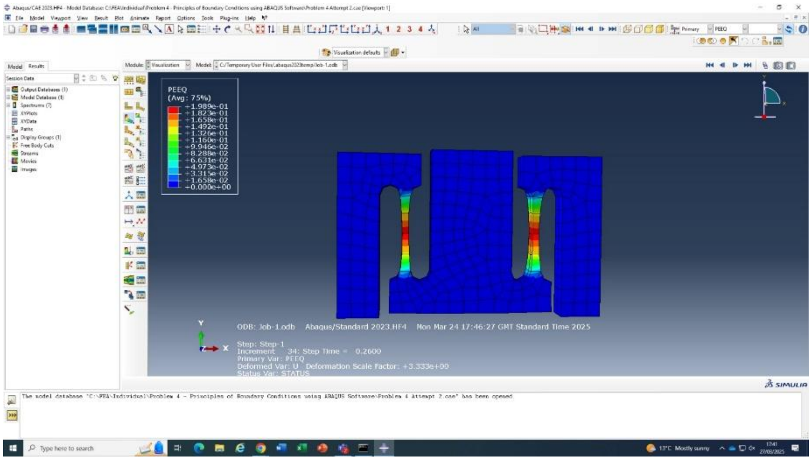

Figure 4.05: PEEQ

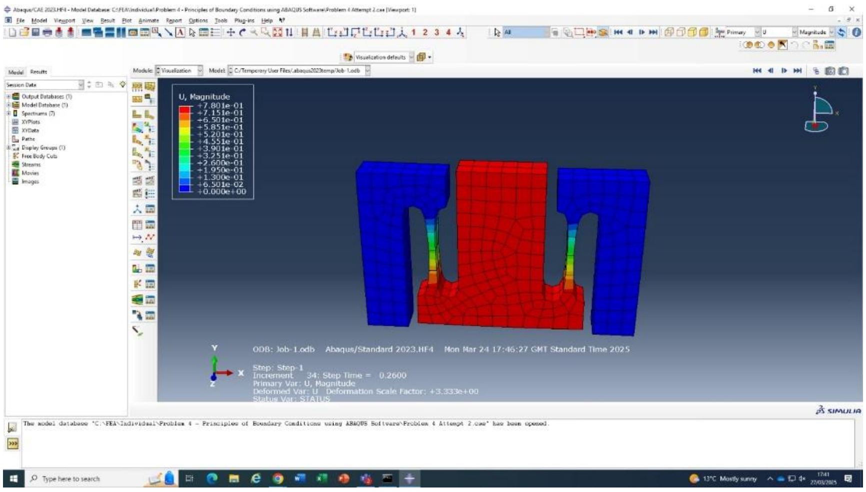

Figure 4.06: Displacement Magnitude

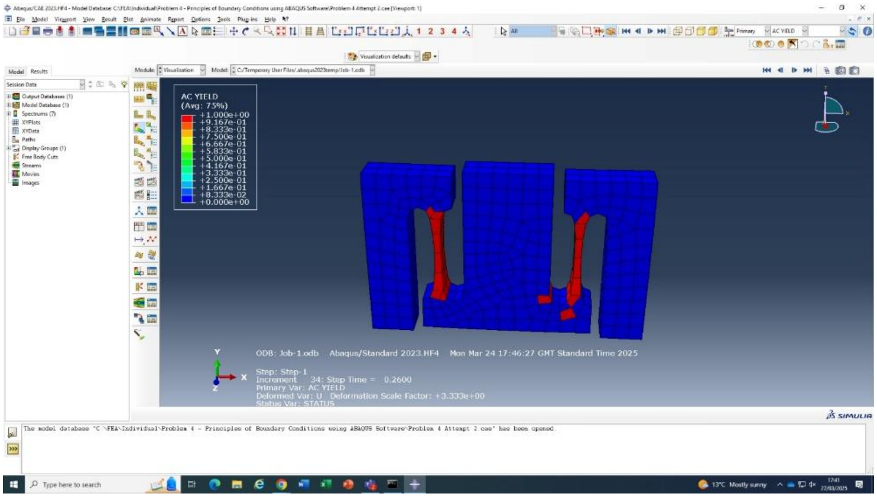

Figure 4.07: AC Yield

The figures above show the stresses and displacements experienced by the structure, the gauge section especially experienced significant stresses but not much displacement. The majority of the displacement was experienced by the middle shape in the geometry.

Part C) Averaged y-stress (S22) and y-strain (E22)

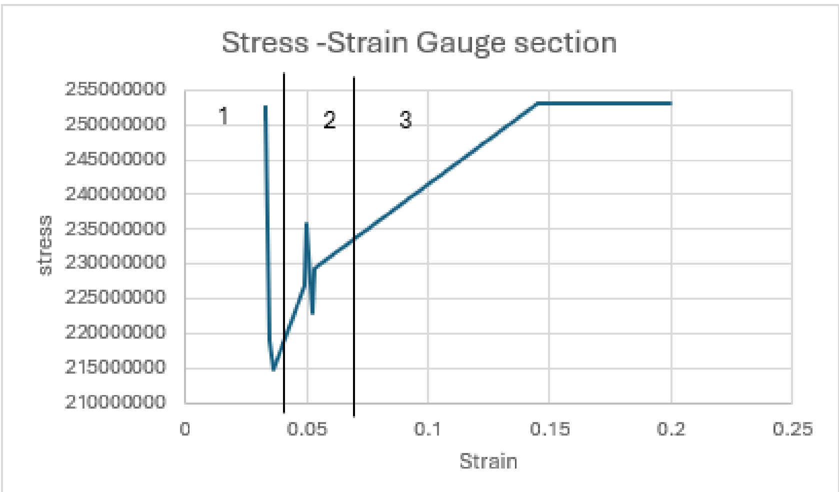

Figure 4.08: Stress(S22)-Strain(E22) graph at the gauge sections

The graph above (figure 4.08) shows the stress-strain curve (vertical axis) at the gauge section. For the sake of explanation, the graph can be split into sections 1,2,3.

Section 1 – shows the initial high stress at the top of the gauge sections and as such the stress is significantly high whilst the actual displacement (strain) is low. This is seen in the figures 4.04 and 4.06.

Section 2 – shows the middle section of the gauge section. In this section the strain is increasing as shown in figure 4.06 as well, in this section however, the stress is approximately 2.3×10^8 N/m^2 which is still high but lower than the stress in section 1 (2.5×10^8 N/m^2) shown in figure 4.04. Due to decrease in stress and increase in the strain the stress strain curve reduces.

Section 3-

Displays the proportional increase, in this situation the stress is in the bottom ends of the gauge section reducing to approximately 2.1×10^8 N/m^2 however the bottom end of the gauge section still has relatively low displacement hence producing the somewhat familiar nature of the traditional stress-strain curve.

Part D) Sources of Error

There are a few possible sources of error when doing simulations (numerical studies), in this case the error between the analytical and numerical study was approximately 1.22% As shown from the graph, the highest achieved stress was around 253MP which is higher than the reported 250MPa in the table provided in the question booklet. This source of error can be explained by a few different reasons.

- Mesh Type

The mesh type i.e. the element type (as discussed in problem 2) can be problematic if the wrong one is chosen. In this study the mesh type chosen was the hexahedral element type. This type has a square structure and as such is not always the correct option for geometries with curves or sharp corners i.e. anything complex. Due to this square nature the element struggles to capture the curvatures and vertices correctly and will often either overcompensate in terms of accuracy which could be why the stress was reported to be higher. If an element type such as the tetrahedral element was chosen the results could be more accurate as the triangular shape can approximate the geometry much better than the hexahedral method for a given mesh size and as such produce much more accurate results

- Mesh Size

Mesh size is another source of error. This source of error often involves striking a balance between the accuracy and computational cost. A smaller mesh size will produce significantly more accurate results relative to one that is larger but will result in significant computational cost. For this study, the default mesh size (about 2) was used, a smaller mesh size will result in higher accuracy but also results in higher costs.

- Boundary Conditions

Boundary conditions are also another source of error, if the problem is not modelled correctly in the software, the analysis will be incorrect regardless of mesh size and mesh element. For example, in this problem the bottom of the structure as whole was fixed in all planes of movement (XYZ) this is to simulate how the geometry will experience displacements in real life as well. If that B.C wasn't applied the displacement would cause the whole geometry to move down in the Y axis which wouldn't replicate what will happen in real life where the geometry would be clamped in place.