Parameter ID – SolidWorks FEA

Procedure

Identified Geometry

For modelling the deformation, I chose the rigid link p_D - p_A from our system kinematics (see fig 1). The axial motion of this link will be responsible for the forward motion of the robot. Our chosen spring and cable system will pull on this link to induce motion. As such, modelling the deformation of this link is necessary as it drives the main motion of the system.

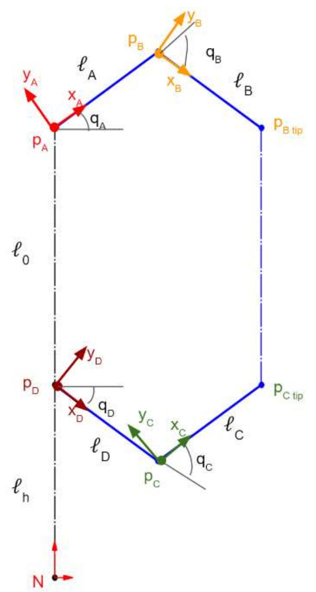

Figure 1 System Kinematics

FEA Simulation tool selection

SolidWorks was chosen to run the finite element analysis of the system. This was chosen due to the ease with which team members can collaborate by working on parts and sharing amongst each other for other purposes. In addition to this, modelling parts in Solidworks is relatively easier. The simulation tool allows for FEA to be done without exporting the part to other software. In the future, COMSOL will be tested to compare the efficacy of both FEA simulation tools.

The image below shows the Solidworks part model of this link.

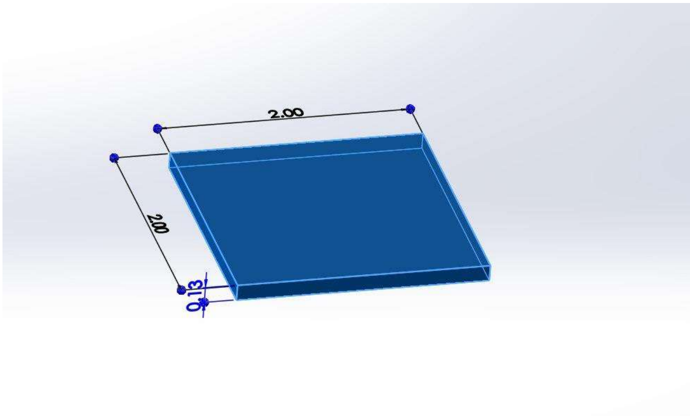

Figure 2 Solidworks Part of link

Boundary and Loading conditions

We used two boundary conditions.

The first boundary condition used was replicating the cantilever experiment. One end of the link was fixed, and a load was applied to the other end to measure the deflection of the entire link.

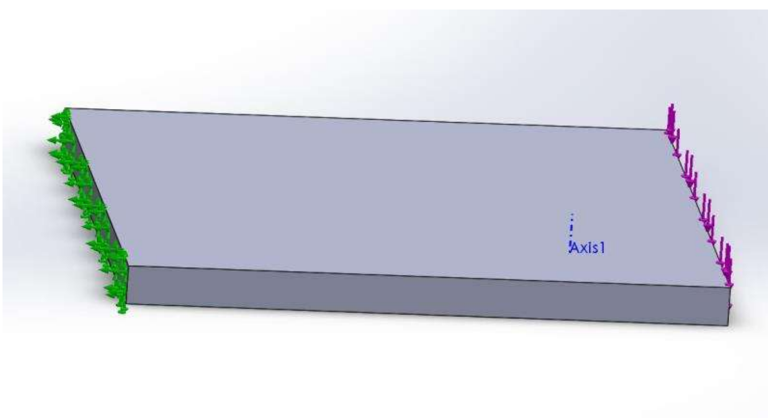

Figure 3 First Boundary and loading conditions

Currently, the team is considering changes to its dynamics and kinematic models. One of such changes is including a leg motion. In this motion, one end of the link moves up before the other does. In other words, one end of the link will be fixed when motion begins.

For loading, the maximum axial burrow force (collected during our system biomechanics)[1] was used. This value was pegged at 0.028 N. Since our link length was scaled to 2inches (a factor of 7.4), we scaled the force by the same factor to 0.2072N.

The second boundary condition fixed both ends of the link and the same force magnitude was applied to the entire surface. This was used to model the entire forward or backward movement of the link. This is being considered as another one of the motions that will be studied by the team. In this motion, the entire link will be pulled by the cable-string combination to induce forward or upward motion, depending on the eventual dynamics that the team ends up with.

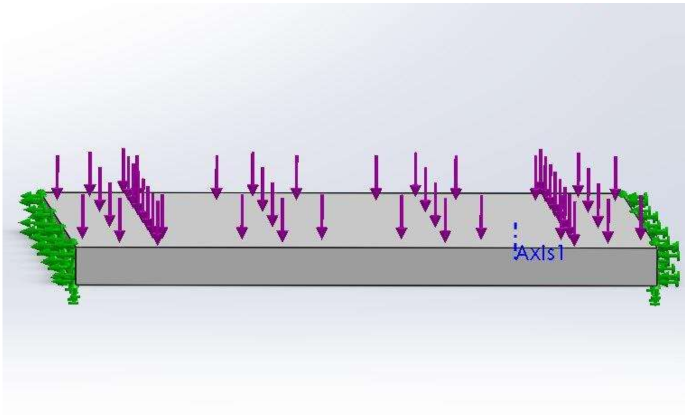

Figure 4 Second Boundary and loading conditions

FEA Results

The following section describes the simulation results for the two boundary and loading conditions.

First boundary and loading condition

The images show the deformation stresses and displacements using two different Young's Modulus for the rigid link.

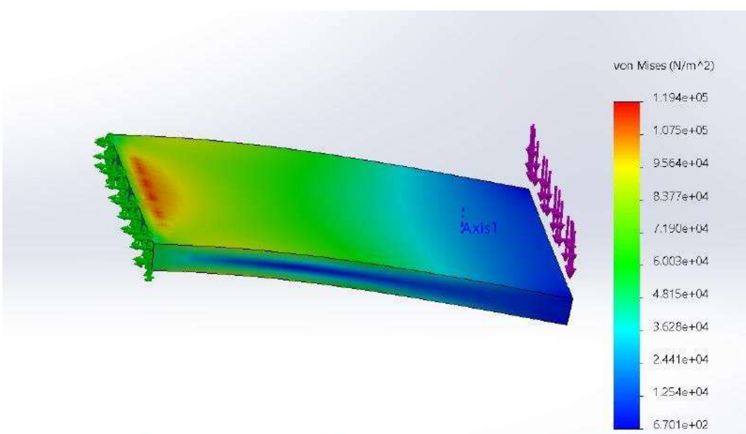

Figure 5 Von Mises Stress for 2000MPa

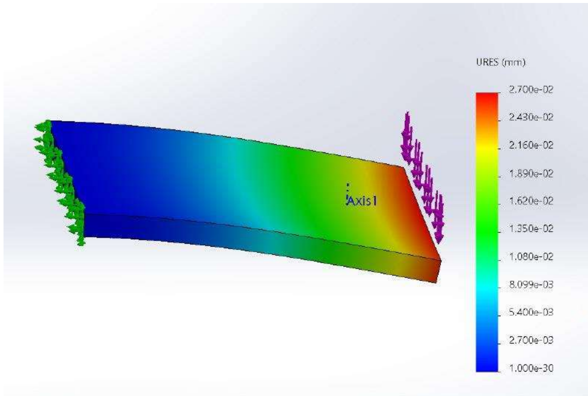

Figure 6 Max displacement for 2000MPa

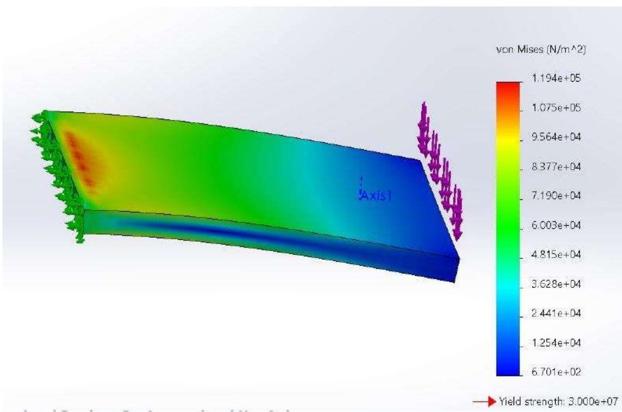

Figure 7 von Mises stress for 12000MPa

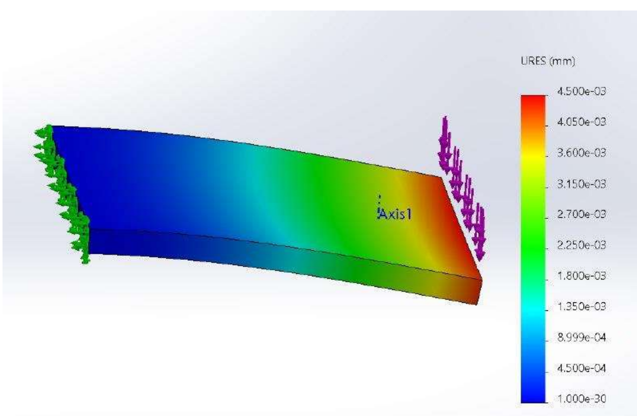

Figure 8 max displacement for 12000MPa

Second boundary and loading conditions

The images show the deformation stresses and displacements using two different Young's Modulus for the rigid link.

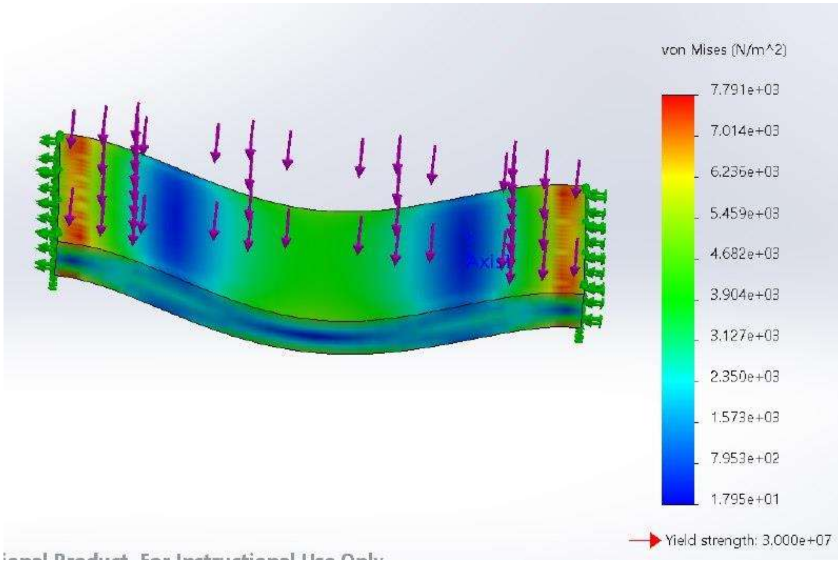

Figure 9 von Mises Stress for 12000Mpa

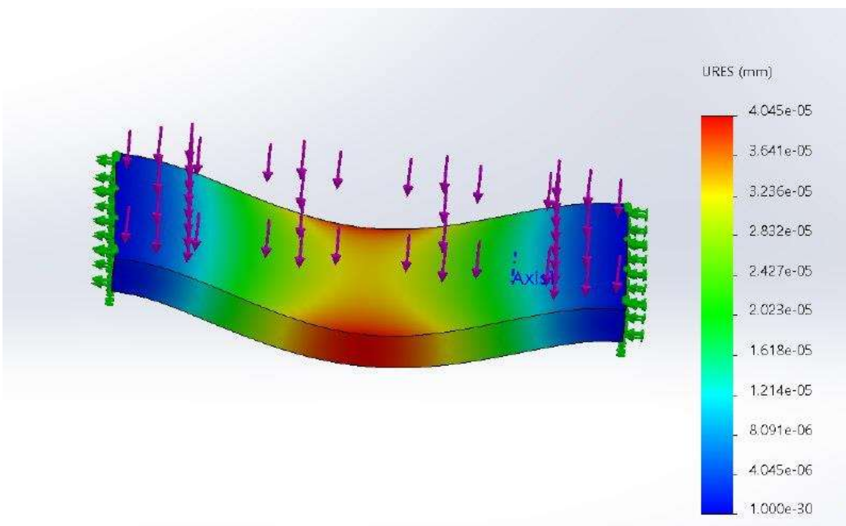

Figure 10 max displacement for 12000MPa

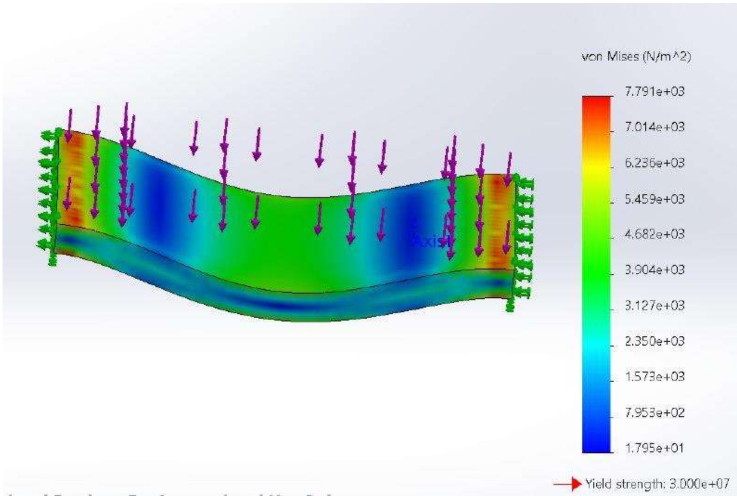

Figure 11 von Mises Stress for 2000MPa

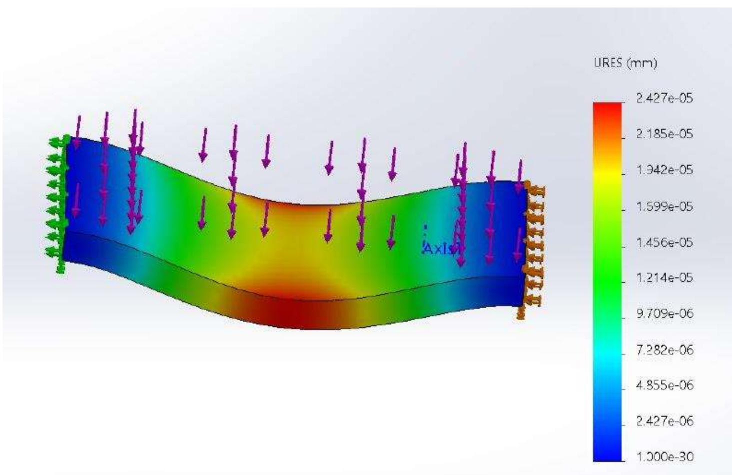

Figure 12 max displacement for 2000MPa

Discussions

In each condition, the maximum von Mises stress was the same regardless of the change in the young's modulus. The most stress was shown at the position of the fixtures.

However, the displacement increased with an increase in the Young's modulus for the second boundary and loading conditions whereas there was an inverse relationship in the first loading and boundary conditions.

This suggests that the Young's Modulus does not influence the stresses imposed on the link. This assumption will be further tested in future tasks.

The discrepancy in Young's Modulus and displacement as a function of the loading conditions will also have to be further explored.

However, the current results show that increase in link stiffness will be generally useful for the entire system.

Geometry Failure

System failure now is not entirely clear, given the discrepancy in Young's modulus and displacement. However, it is somewhat evident that the system is liable to fail more under the first loading and boundary conditions as the most stresses are experienced in that condition. The most deflection is experienced in that configuration as well.

Assumptions and future tasks

There was logistics trouble in securing all the necessary materials to perform the cantilever beam experiment. These are being resolved and the data from those will be collected and included in future reports. In addition, the results will be used to re-run the SolidWorks simulations in this assignment.

The experimental value for the Young's Modulus used in this assignment was acquired from prior work in the mechanical and physical properties of paper. Two publications [2][3] were used to choose a range of 2000 to 12000 MPa for the Young's Modulus of paper.

References

[1] K. J. Quillin, “Ontogenetic scaling of burrowing forces in the earthworm Lumbricus terrestris,” *J. Exp. Biol.*, vol. 203, no. 18, pp. 2757–2770, 2000.

[2] B. Sekulic, “Structural cardboard: feasibility study of cardboard as a long-term structural material in architecture,” pp. 1–64, 2013.

[3] S. Allaoui, Z. Aboura, and M. L. Benzeggagh, “Contribution to the Modelling of the Corrugated Cardboard Behaviour,” 2011.