Lab #4

Static Analysis of a Link

&

Static Analysis of a Hanger

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Abstract

Two methods of analyzing the stress and displacements of a link with 2 pinned connection and applied load at one hole is used, an analysis using just half the link to utilize symmetry and ana analysis of the whole link with the same constraints. In the second portion of the lab various contact connections (contact, bonded and free) are explored in the analysis if the stress and displacement of a hanger. Such a study will establish a more concrete view of proper connections needed in terms of its purpose.

Introduction

In the use of FEA, various techniques may be applied to simplify the overall computational time and complexity of the analysis. The use of symmetry may be applied to explore such properties such as stress and displacement. However, it is important to note that parts must be symmetric in both geometry and load/constraints for such technique to be applied. Symmetry is limited in the results it may obtain as in the analysis of the link. The contact stress of the pin and link cannot be determined through the use of symmetry.

Properly constraining your FEA study is vital to achieving the proper results. One such parameter to be aware of is the contact hierarchy. By default, the interactions of parts in your study are placed as bonded. However, depending on the specifications of the requirements of one's specific study, such can be changed. Contact connections, via the local level is one other example in which parts are allowed to move from the structure. Free connections are those that allow a face to ignore the obstacles of other parts. Properly defining the relations is important in both a static and dynamic study of parts.

Theoretical Background

Symmetry is used to simplify the FEA of certain models. Within the link, symmetry is taken advantage of due to the symmetric loading and constraints within the pin connections. To do so, along the axis of symmetry, any applied load should be cut in half. Local interactions between parts can be individually changed based on the requirements of the study. The default global contact would be a bonded contact, but different contacts include free and contact (with spacing).

Graphical Demonstrations of SolidWorks Results

study type	Max von Mises Stress (Mpa)	Max Displacement (mm)
symmetry	167	0.2798
whole link	165.4	0.2797

Table 1: Max von Mises Stress and Max Displacement of a link with a symmetric and whole link study type.

Contact Type	Max von Mises Stress (Mpa)	Max Displacement (mm)
Contact 01	198.77	2.2632
Contact 02	416.322	6.7015
Bonded	199.127	0.657
Free	416.32	6.7015

Table 2: Max von Mises Stress and Max Displacement of a hanger with different contact type between the bottom face of the horizontal support onto the verticals support to analyze

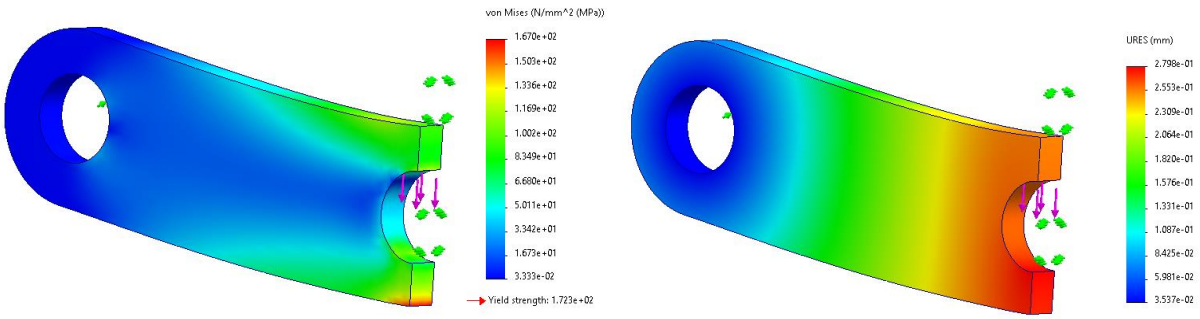

Figure 1: A static study of a link using a symmetry to analyze (A) Max von Mises Stresses (left) and (B) Max Displacements (right).

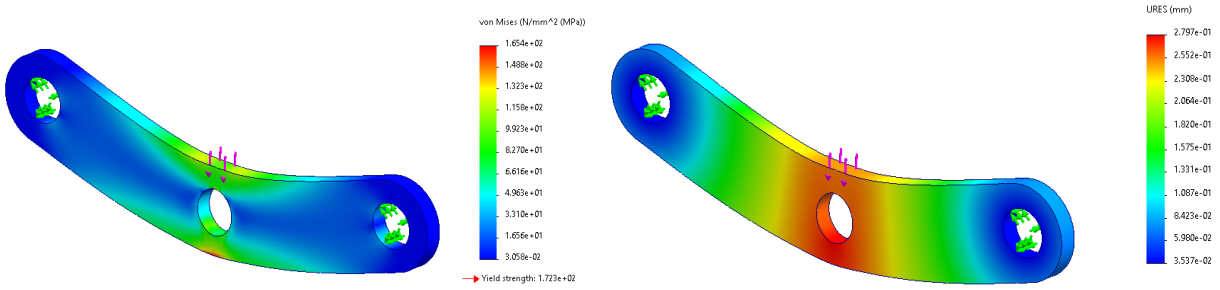

Figure 2: A static study of a whole link to analyze (A) Max von Mises Stresses (left) and (B) Max Displacements (right).

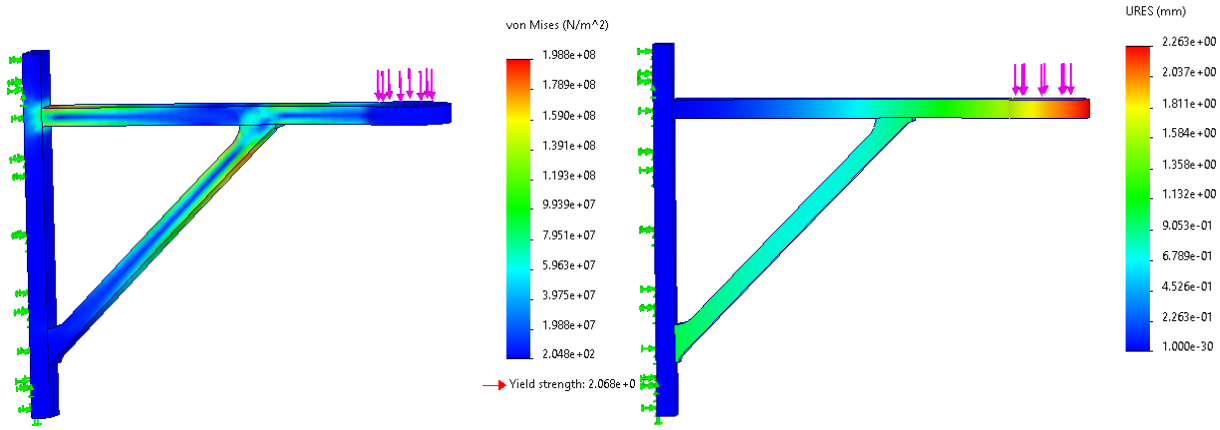

Figure 3: A static study of a hanger with a contact type connection between the bottom face of the horizontal support onto the verticals support to analyze (A) Max von Mises Stresses (left) and (B) max displacement (right).

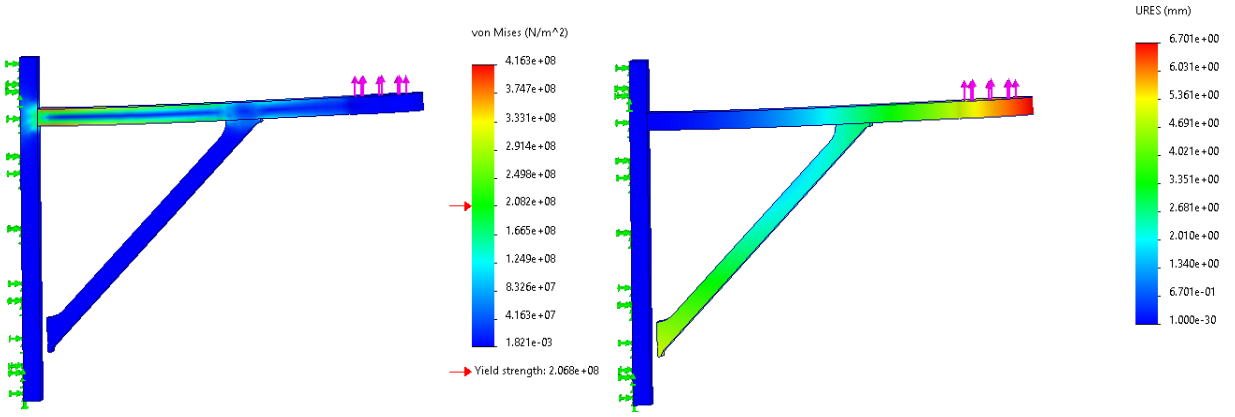

Figure 4: A static study of a hanger with a contact type connection with a upward 1000 N force between the bottom face of the horizontal support onto the verticals support to analyze (A) Max von Mises Stresses (left) and (B) max displacement (right).

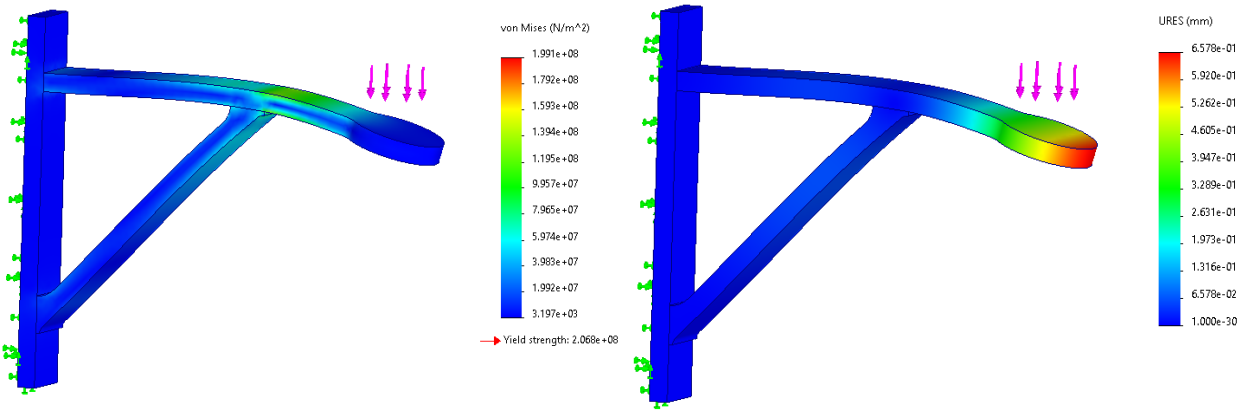

Figure 5: A static study of a hanger with a bonded type of connection between the bottom face of the horizontal support onto the verticals support to analyze (A) Max von Mises Stresses (left) and (B) max displacement (right).

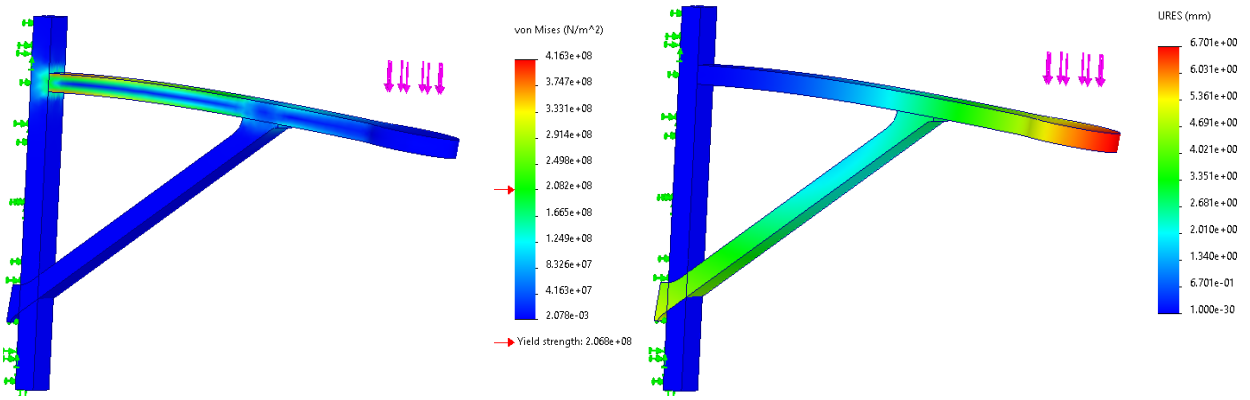

Figure 6: A static study of a hanger with a free type of connection between the bottom face of the horizontal support onto the verticals support to analyze (A) Max von Mises Stresses (left) and (B) max displacement (right).

Discussion and Interpretation of Results

In the first portions of the lab, two methods of analyzing the stress and displacement of a link were analyzed using symmetry and through a look at the entire link. The values are seen to be close (Table 1) which is to be expected based on applying the proper constraints of symmetric boundary conditions. Stresses and displacements distribution can be seen to match as seen in Figures 1-2. It can be found that the max stress and displacements values are similar. Such method of symmetry works for the purpose of these parameters by properly defining the symmetric boundary conditions.

In the second portion of the lab, various contact type was used to find the max von mises stress and max displacements. Under the same applied load downwards, it was found that the free contact types between the vertical and bottom support resulted with the largest max von Mises stress, coupled with the largest max displacement (Table 2). The by allowing for more displacement, the connection on the top (Figures 3-6A) would experience the most stress. Allowing more displacement increases the stress concentration within that point. However, it can also be observed that with the although the bonded connection has a smaller max von Mises stress, it experiences fewer overall displacements. With contact that isn't constrained completely like through a bonded connection, there is a degree of freedom for the part to move and distribute stress rather than constrained stress at the edge. The concentrated at a different area (Figure 5). The free contact support is also seen to have a max stress above the yield strength, signifying that the structure will fail at the area of highest stress concentration. Such contact type doesn't allow the support part from providing support to help distribute the stress through the structure.

Conclusions

Symmetric boundary conditions are a way to reduce the total computation time and complexity within a static FEA study. The local interaction that is defined can greatly affect the stress concentrations due to the allowed freedom of the movement of the parts. A free contact connection was seen to have the highest stress concentrated due to the lack of support from the part. Connections may change the amount but also the location of the concentrated stresses.

References

[1] Engineering Analysis with SolidWorks Simulation 2024, by Paul Kurowski (2024), ISBN-10: 1630576298.
[2] A First Course in the Finite Element Method, Enhanced Edition, 6th Ed., by Daryl Logan (2022), ISBN-10: 0357884140