ASE 375 Laboratory 9: Digital Image Correlation (DIC)

Week of 8 April 2024

The goals of this laboratory are to:

- Measure two-dimensional strain distribution using Digital Image Correlation (DIC).
- Learn how a universal testing machine works.
- Investigate stress concentration around a hole.

Lab exercises:
In this lab you will perform a tensile test on a aluminum strip and a polycarbonate strip. Each test article has a hole in its center. Tensile load will be applied using a universal testing machine till the test article fails. The strain distribution will be measured using DIC.

1. Measure the width and thickness of the test article, and the diameter of the hole.
2. The material parameters are given in Table 1.
3. Mount the test article in the grips of the Instron testing machine. Load the configuration file in the Bluehill software.
4. Use the Windows Camera app to capture images of the test article. Position and focus the camera so that a region of the test article including the hole and some of the surrounding material is clearly visible. You may have to adjust some of the settings in the camera app.
5. Capture an image of the test article - this will be your "reference" or undeformed image.
6. Start the Instron machine in the Bluehill software. As the tensile force increases, the test article will undergo deformation. At every 100 N step in applied load for polycarbonate (1 kN step for aluminum), save an image of the test article using the Windows Camera app. The Instron machine will automatically stop when the test article fails.
7. Perform the above steps for both the aluminum and the polycarbonate test articles.
8. Use the "GOM Correlate" software to analyze the images you captured and find the strain distribution. The included tutorial videos are a good resource to understand how to operate the software (for example, the video titled "2D Evaluation of Surface Components").
9. Plot the force vs. displacement for each test article. Discuss how/ why the two test articles have different characteristics.
10. Show the strain distribution at an applied load of 6 kN for the aluminum test article and 1 kN for the polycarbonate test article.
11. Compare the measured stress concentration with the theoretical value at an applied load of 6 kN for the aluminum test article and 1 kN for the polycarbonate test article.

12. Plot the maximum strain (at the edge of the hole) as a function of the applied load for both the test articles.

NOTES:

- The theoretical stress distribution in the test article is shown in figure 1. The nominal stress in the test article at a cross-section containing the hole diameter (shown as a dashed line in figure 1) is

$$\sigma_{\text{nom}} = \frac{P}{t(D-d)} \tag{1}$$

where P is the applied tensile load and t is the thickness of the test article. If the maximum stress is σ_{max}, the stress concentration factor is defined by

$$K_t = \frac{\sigma_{\text{max}}}{\sigma_{\text{nom}}} \tag{2}$$

The theoretical stress concentration factor is (for $0 \leq d \leq D$)

$$K_t = 3 - 3.14\left(\frac{d}{D}\right) + 3.667\left(\frac{d}{D}\right)^2 - 1.527\left(\frac{d}{D}\right)^3 \tag{3}$$

	Aluminum 7075-T6	Polycarbonate
Elastic modulus	71.7 GPa (10,400 ksi)	Avg. 2 GPa (290 ksi)
Yield Strength	503 MPa (73 ksi)	62.0 MPa (8.99 ksi)
Approx. Yield Strain	0.7%	7.0%
Poissons Ratio	0.33	0.37

Table 1: Material parameters of test specimens

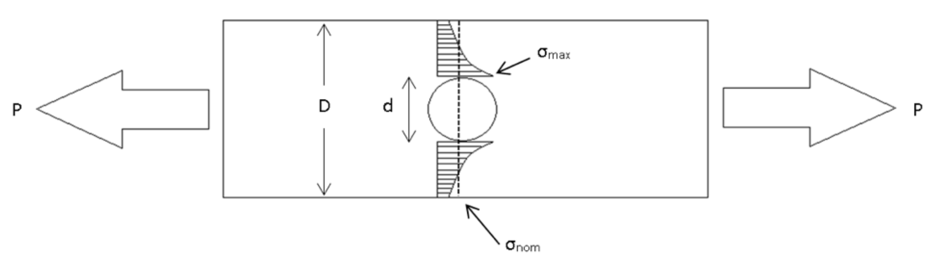

Figure 1: Theoretical stress distribution