Exploration of the Compressive Properties of EPON 826/LS-81K Epoxy

Jason Chen, Evans Frandsen, Jason Carey, Ahmed Samir Ead

UNIVERSITY OF ALBERTA

Engineering at Alberta

1 Introduction

Figure 1: Solid model of TBC

Tubular braided composites (TBCs) are tubular structures made by interlacing fibers over a mandrel at adjustable angles. Once interlaced, the fibers are cured with an epoxy resin to create a matrix that binds together the reinforcing fibers, forming the final composite, shown in Figure 1. TBCs have a wide range of applications in the aerospace and automotive industry due to their light weight and high strength. However, to fully leverage their potential, it is crucial to understand its failure modes under compression.

Hence, epoxy compression samples were created and tested in compression to confirm the failure mode of the epoxy. This will then be compared with the failure mode of TBCs under compression and the predicted failure mode derived from the torsion tests.

Epoxy resin's shear strength is predicted to be a major factor in determining the failure mode of TBCs under compression. Torsion tests can be conducted on epoxy samples to experimentally determine its shear strength [1]. The theoretical failure mode of TBCs under compression can then be found using the experimental shear strength through the model prediction in Figure 2.

Two major factors that determine failure mode of TBCs in compression:

1. Modified Load Factor, $\frac{PE^2}{t^2k^3}$
   a) Load, P
   b) Length, l
   c) Elastic Modulus, E
   d) Shear strength, k
2. Modified Shape Factor, $\frac{k\Phi}{E}$
   a) Shape efficiency, $\Phi = \frac{r}{t}$
   b) Radius, $r = \frac{d_o}{2}$
   c) Thickness, $t = \frac{d_o - d_i}{2}$

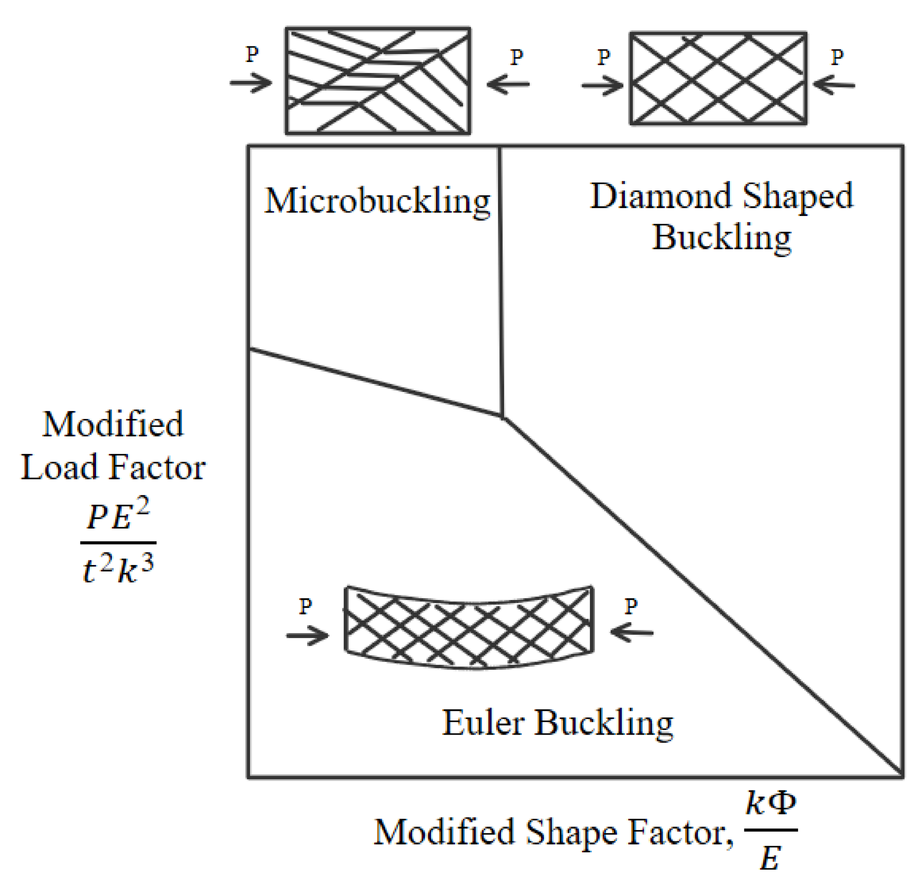
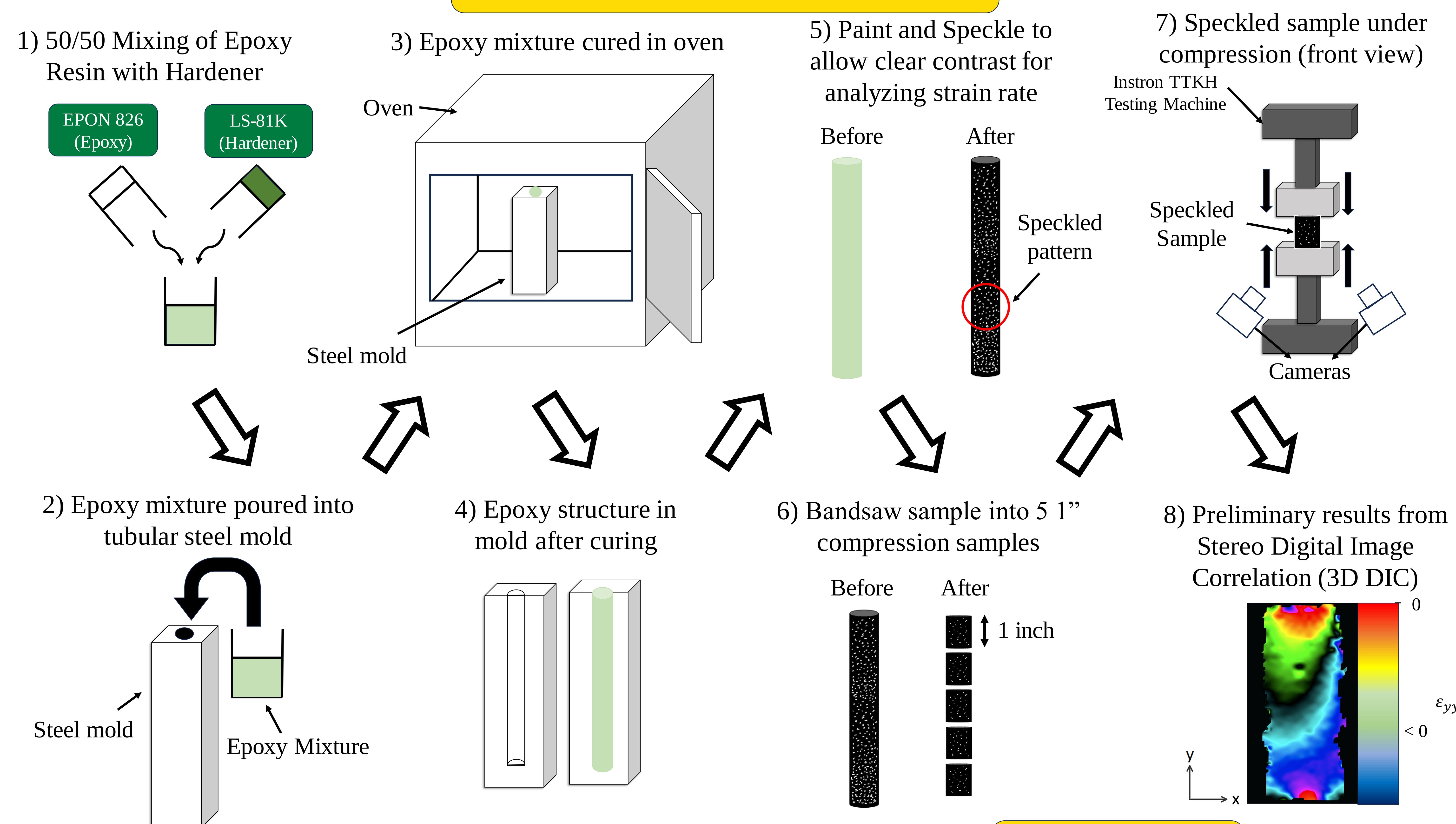


Figure 2: Shape efficiency map for TBCs recreated from Harte and Fleck [2]

2 Background

Epoxy resin is considered a homogenous, isotropic material with a brittle tensile failure and a tensile Young's modulus of $E = 2730\ MPa$ [3]. However, findings from other research papers suggest that epoxy resin may have a ductile compressive failure [2] [4]. Epoxy compression test results allows for the verification of failure mode and comparison between tensile and compressive Young's Modulus.

3 Manufacturing and Testing



4 Analysis

After the testing is complete, load data is extracted from the Instron TTKH testing machine and combined with deformation data from the 3D DIC to create a stress strain plot as shown in Figure 3.

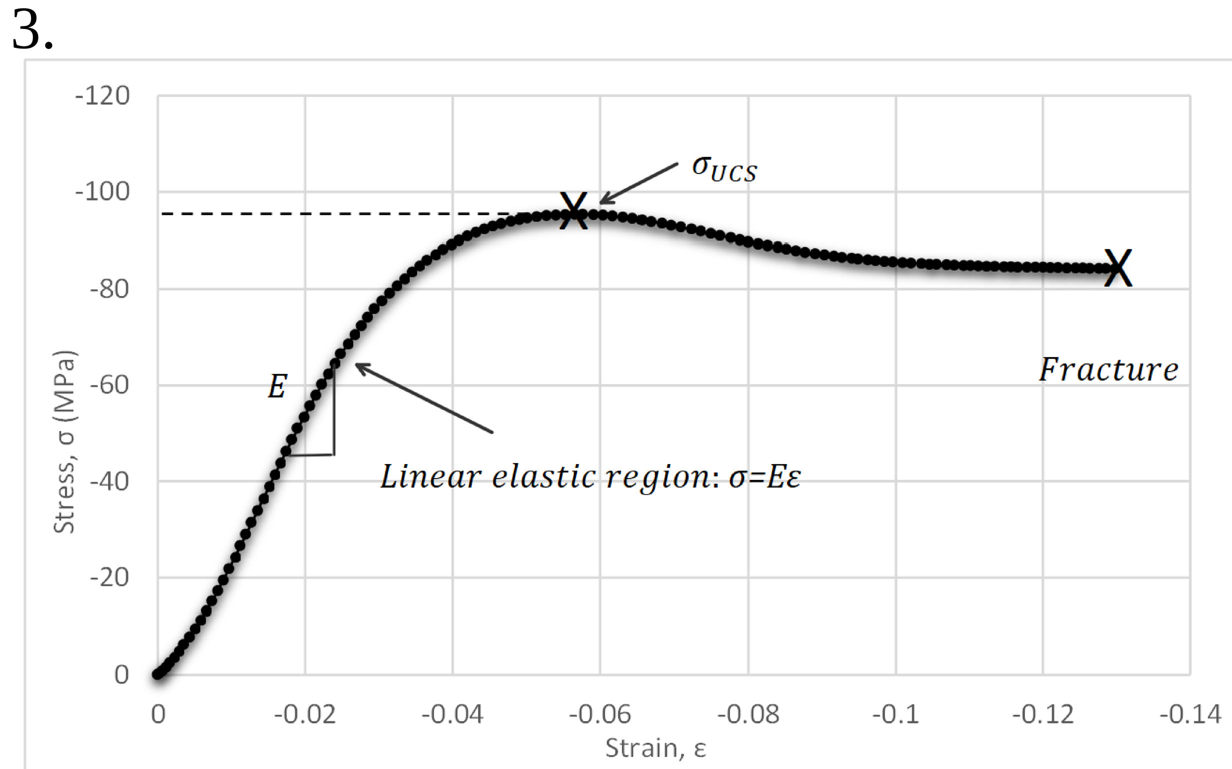


Figure 3: Stress-strain curve from experimental data

The compressive Young's modulus of the epoxy sample is average of the slope of the linear elastic region across 5 samples and is determined to be $E = 2640 \pm 270\ MPa$.

5 Conclusion

From the compression test results, it can be seen that epoxy exhibits ductile yielding but a brittle fracture. The compressive Young's modulus is also approximately equal to the tensile Young's modulus, indicating signs of isotropy for epoxy. The next step is to determine shear strength of the epoxy with torsion tests and the failure mode of TBCs under compression.

6 References

[1] Pearson Canada, "Engineering Mechanics: Dynamics SI Package (11th edition)" 2006.

[2] Harte, A. M., & Fleck, N. A. (2000). DEFORMATION AND FAILURE MECHANISMS OF BRAIDED COMPOSITE TUBES IN COMPRESSION AND TORSION

[3] Westlake Epoxy., "Epoxy Resin System for Pultrusion or Filament Winding EPON™ Resin 826 or EPON™ Resin 862 / LS-81K Anhydride Curing Agent (MTHPA)"

[4] Y. Hu, Z. Xia, and F. Ellyin, "The Failure Behavior of an Epoxy Resin Subject to Multiaxial Loadings" 2006.