VIRGINIA COMMONWEALTH UNIVERSITY

VCU School of Engineering

TESTING of LIGHTAPE PRODUCTS

Through: Virginia Commonwealth University

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Introduction:

The objective of this testing was to see how the interior and exterior coverings of lightape products would respond to tensile and three point bend testing. The tensile test works by gauging the forces required to stretch a specimen to its braking point. After testing is finished it provides data on the reliability and safety of a material. The material properties can then be determined through the data collected. The three point bending flexural test provides values for the modulus of elasticity, flexural stress, flexural strain, and the flexural stress-strain response of the material. This test is often used to select a material for parts that will support loads without flexing. However, this is not the case for the lightape product which is very flexible. Therefore when this test was done the lightape product was fastened down using a clamp.

Procedures:

For the tensile testing we used the MTS30 machine. The MTS30 machine was equipped with grippers which clamped down on both ends of the test strips. Two different sizes were used for the tensile testing. The sample sizes were two inch and one-fourth inch strips. On the lab computer, the program TestWorks 4 was used to select MTS Tensile test. Then the Test Speed was set to 1 in/min and the Data Acquisition Rate set to the same. The break detection was enabled and the test procedures were set to the dimensions of the test samples. The controllers on the program were used to place the top part of the MTS machine down in the proper position to attach the lightape sample. Once it was in the proper position each of the channels were zeroed. This clears out any data collected before the test was performed. The play button was clicked to run the test. Before the test began a text box appeared asking for the width and thickness of the specimen which was measured and put in. Once the test was finished, the Review button was clicked to see the results. After viewing the results of the test, they were saved and the test was repeated with the rest of the lightape products.

For the three point bend testing we used the Instron® Model 5948 MicroTester. We began by logging into the BlueHill program. The dimensions of the lightape product used for this test were the two inch strips. The thickness was measured and input into the program. We used a clamp to fasten the flexible tape to the machine. The load-head was moved so that it was touching the test specimen. This had to be done carefully because if the load-head was not completely touching the specimen when the test started, the first few rows of data would have been invalid. After the load-head was placed correctly the balanced all option was used to zero all the channels. Then the entire procedure was repeated for the other lightape products.

Results:

The results found from the tensile and 3 point bending test demonstrated several characteristics of the interior and exterior coverings. Several lightape Specimens where tested with varying sizes. After the specimens were tested through the MTS30 machine for its tensile test the specimens were checked to see if they could still light up. For the most part the specimens stopped working. However, the lightape was then tested to see how long the test could run until the lightape would stop working. It was recorded that it took approximately 40 seconds for lighting failure to occur. All specimens used in the 3 point bending test were not tested for light failure because this test on an elastic material would not cause such failure. Also 3 point bending tests are usually done with a rigid material. Since the material was elastic and not rigid the specimens had to be clamped down. This is believed to have led to some varying results number wise. However, it would not affect any change in material reaction. This being said the numbers calculated below in the appendixes seem to vary; however, they should be in an approximate range of their correct values. The patterns of the figures, on the other hand, would not be affected by this and are held to be correct.

Therefore, what do the Figures tell us about the interior and exterior coverings? It tells us that the interior covering, although flimsy, is more elastic and can stretch more during the tensile test. This means that the interior material has a higher modulus of elasticity. This is the region in which the material can be stretched and return to its original shape. However, it has a much lower ultimate stress. Ultimate stress is the uttermost tensile/compressive stress that a material is expected to bear without failing. (See **Table 5** in **Appendix B**) Therefore, exterior material can withstand a far greater load, but seem to exhibit less ductile properties then the interior. The more elastic/ductile a material is the more the graphs will display a steeper slope. (See **Figures 9-12** in **Appendix B**)

Appendix A (results from tensile test)**:**

Equations:

E (Young’s Modulus) – is the stress divided by the strain

$$E \equiv \frac{\text{tensile stress}}{\text{extensional strain}} = \frac{\sigma}{\varepsilon} = \frac{F/A_0}{\Delta L/L_0}$$

Equation 1:

Stress – is the force per unit area applied on a cross-sectional area.

Equation 2 $$\sigma_e = \frac{P}{A_o}$$

Strain – is the change in length (extension) divided by the initial resting length.

Equation 3: $$e = \frac{\Delta L}{L} = \frac{\ell - L}{L}$$

Tables:

Table 1: calculated values for 2 inch interior covering

Young's Modulus (Mpa)	0.506
Ultimate Strength (Ksi)	1.16
Engineering Stress at Failure (Ksi)	193.2
Engineering Strain at Failure (in/in)	32.3

Table 2: calculated values for 2 inch exterior covering

Young's Modulus (Mpa)	0.36
Ultimate Strength (Ksi)	0.72
Engineering Stress at Failure (Ksi)	193.2
Engineering Strain at Failure (in/in)	101

Table 3: calculated values for ¼ inch interior covering

Young's Modulus (Mpa)	0.057
Ultimate Strength (Ksi)	0.195
Engineering Stress at Failure (Ksi)	193.4
Engineering Strain at Failure (in/in)	37.5

Table 4: calculated values for ¼ inch exterior covering

Young's Modulus (Mpa)	0.19
Ultimate Strength (Ksi)	0.138
Engineering Stress at Failure (Ksi)	193.0
Engineering Strain at Failure (in/in)	16

Figures:

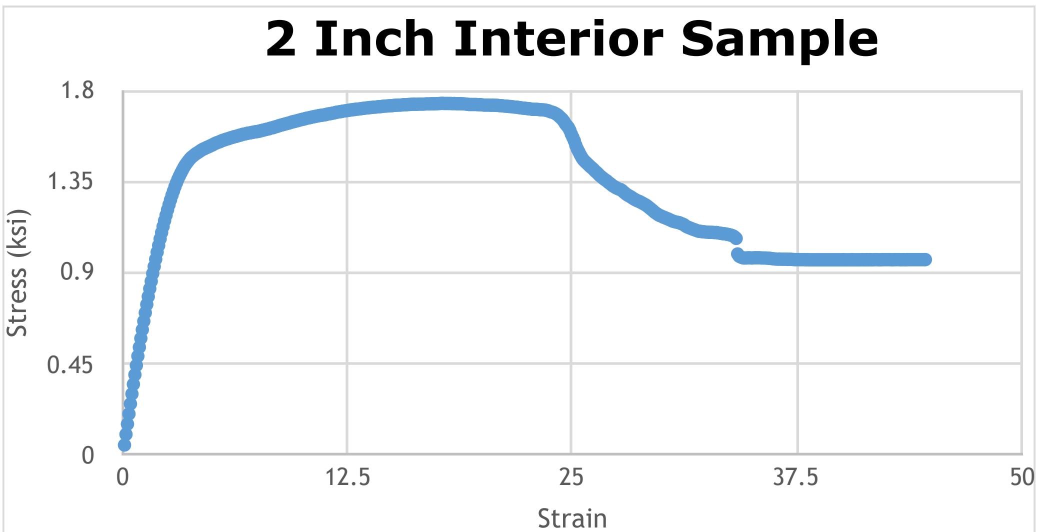

Figure 1: stress vs. strain for 2 inch interior covering

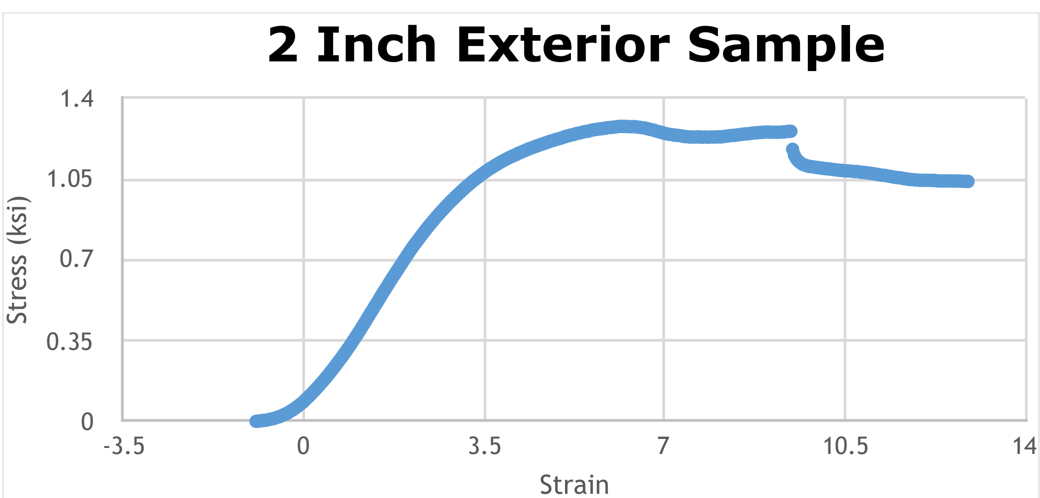

Figure 2: stress vs. strain for 2 inch exterior covering

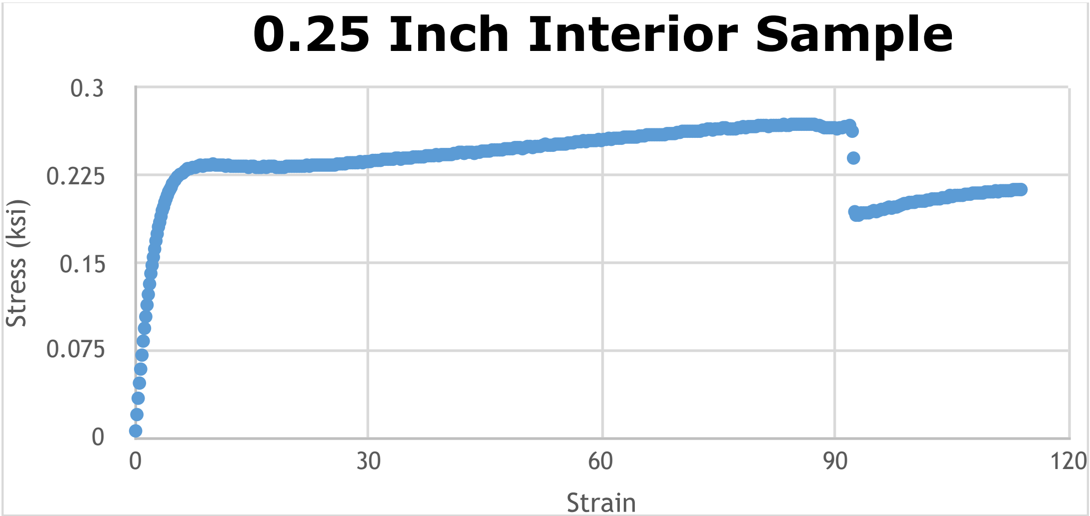

Figure 3: stress vs. strain for ¼ inch interior covering

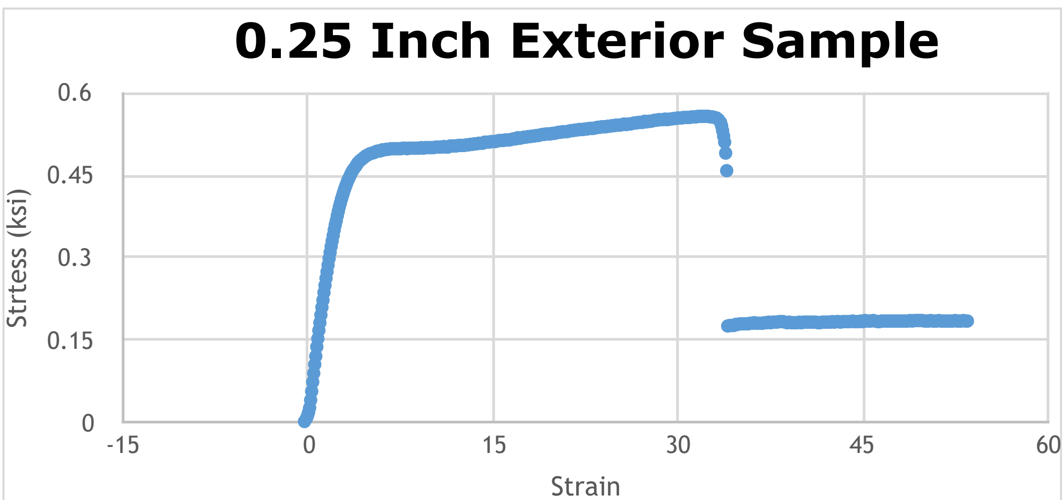

Figure 4: stress vs. strain for ¼ inch exterior covering

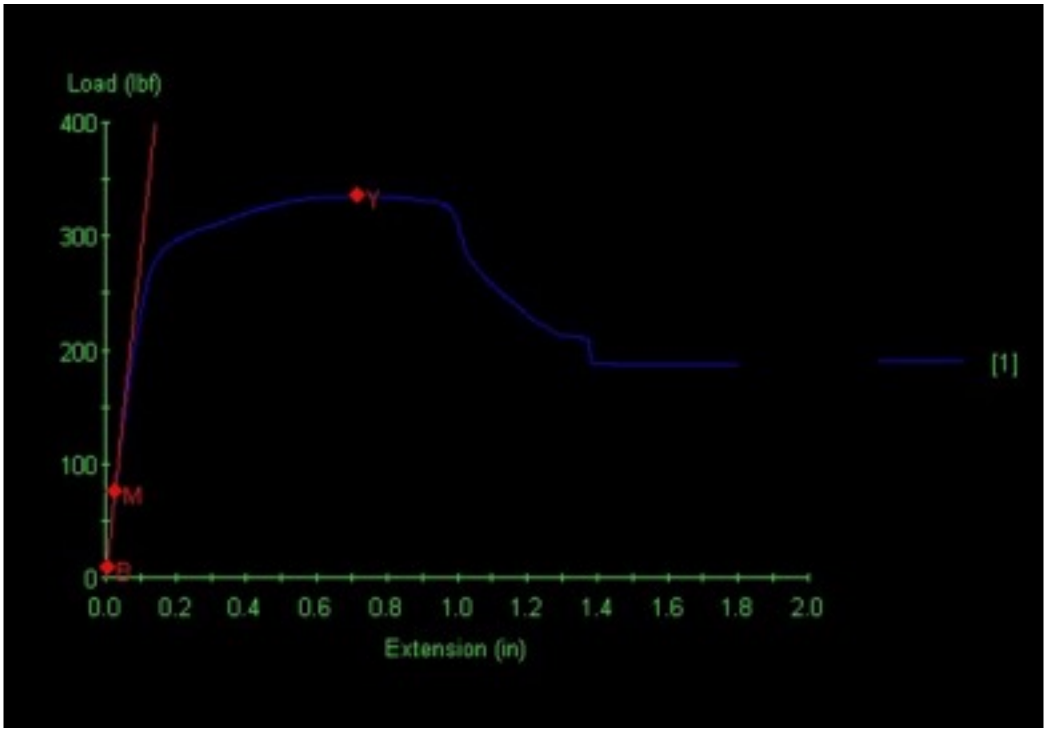

Figure 5: Load vs. Extension from 2 inch interior covering

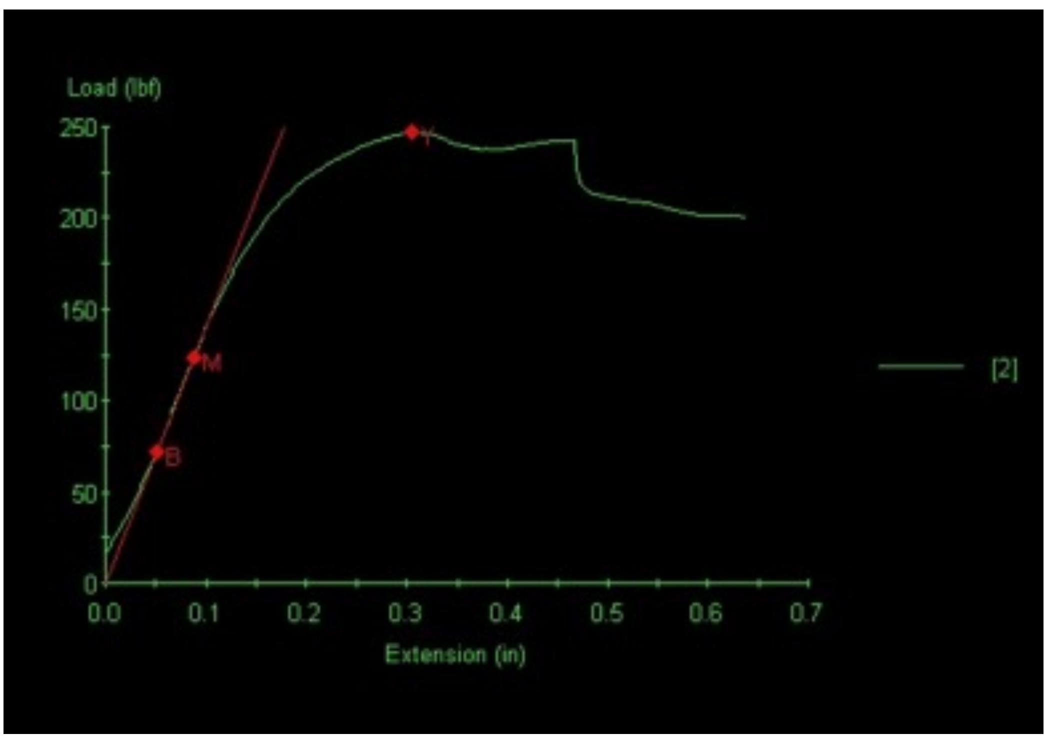

Figure 6: Load vs. Extension from 2 inch exterior covering

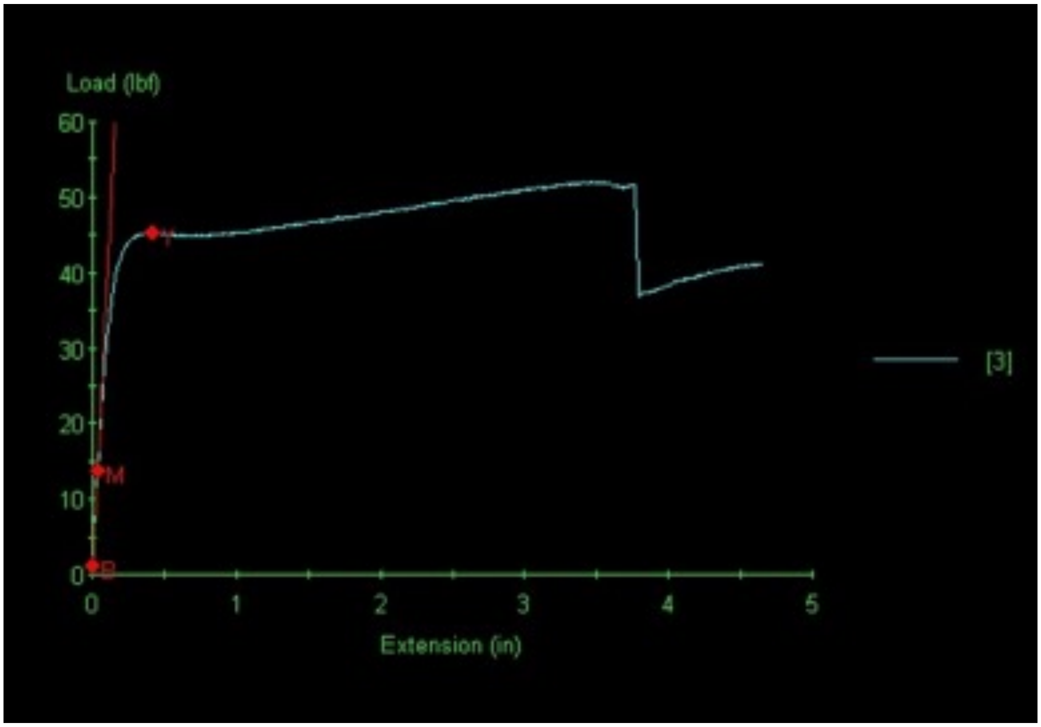

Figure 7: Load vs. Extension from ¼ inch interior covering

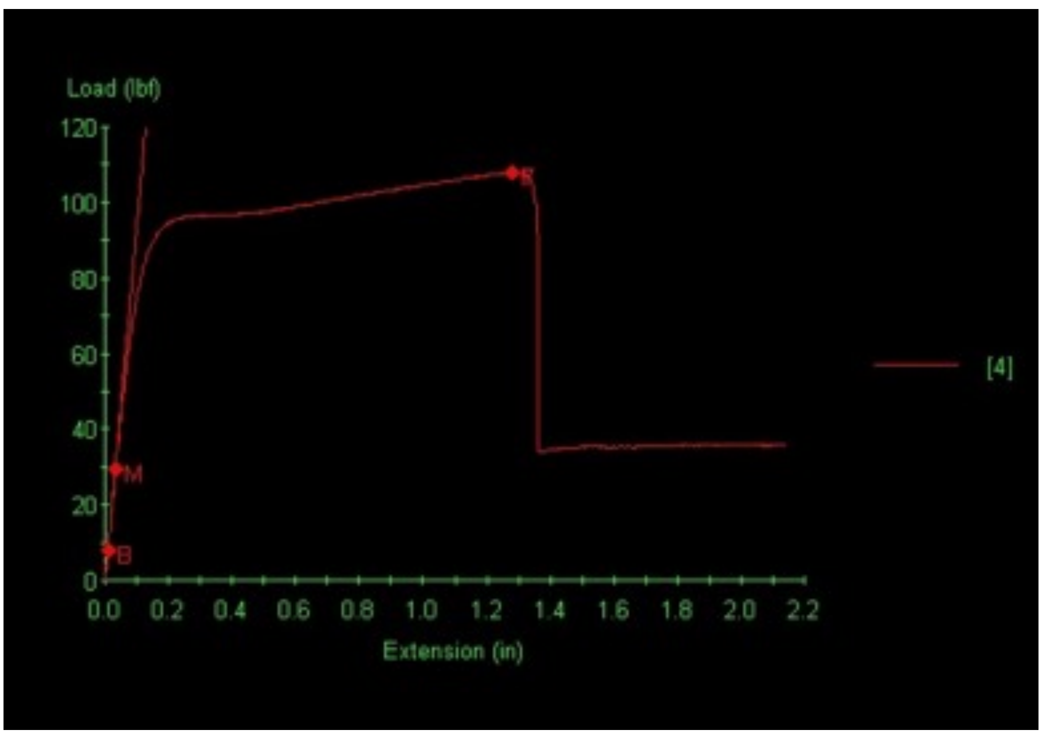

Figure 8: Load vs. Extension from ¼ inch exterior covering

Appendix B (results from 3 point bend test)**:**

Equations:

Bending Stress – is the tensile or compressive stress resulting from the application of a non-axial force.

Equation 4:

Where:

M – Internal bending moment (maximum will occur at for our case)

c – Distance from specimen to outer fibers

I_{xx} – Moment of inertia of cross section =

F – Applied load

Maximum Bending Stress

Equation 5:

Maximum Deflection

Equation 6:

Tables:

Table 5: Estimated Values from Figures below

	Elastic Modulus (MPa)	Ultimate Stress (MPa)
2 inch interior run_1	40,650	100
2 inch interior run_2	25,000	60
2 inch exterior	16,600	375

Figures:

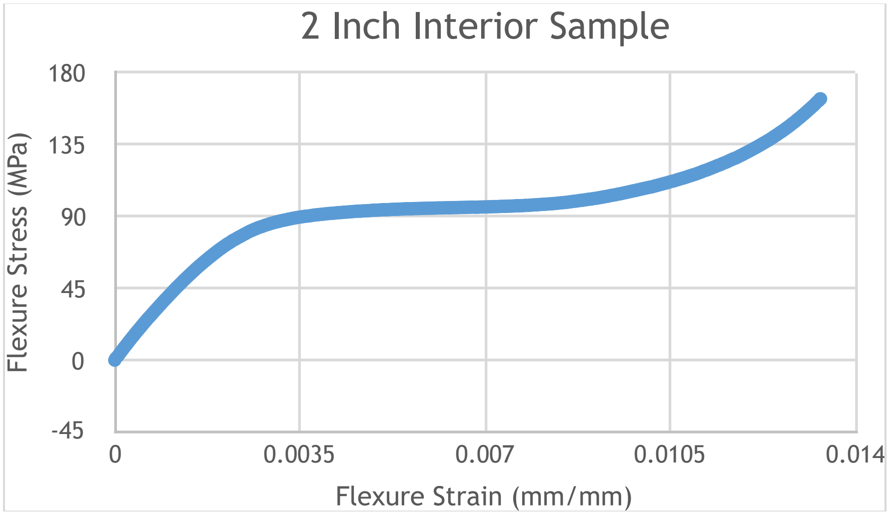

Figure 9: Stress vs. Strain from 2 inch interior covering run_1

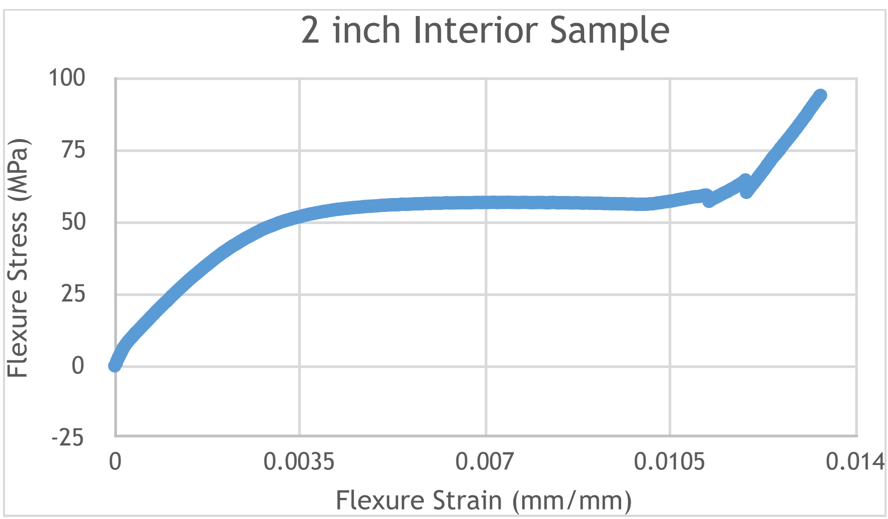

Figure 10: Stress vs. Strain from 2 inch interior covering run_2

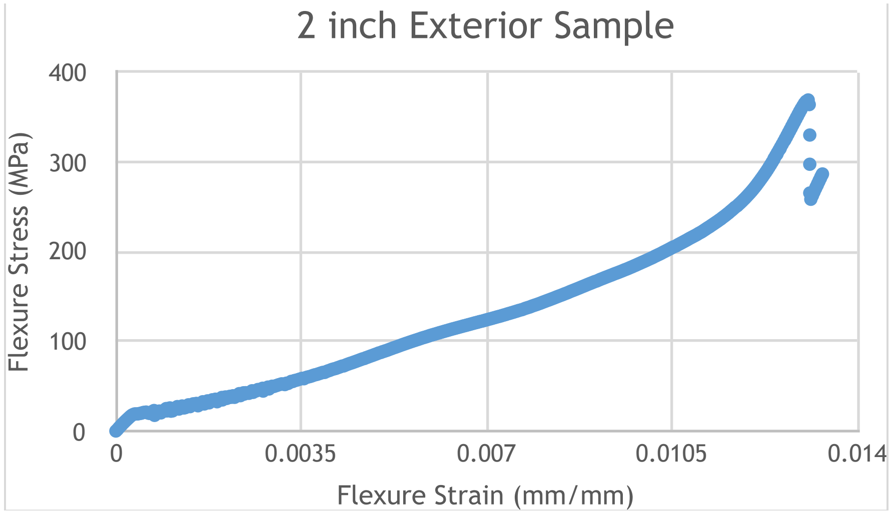

Figure 11: Stress vs. Strain from 2 inch exterior covering

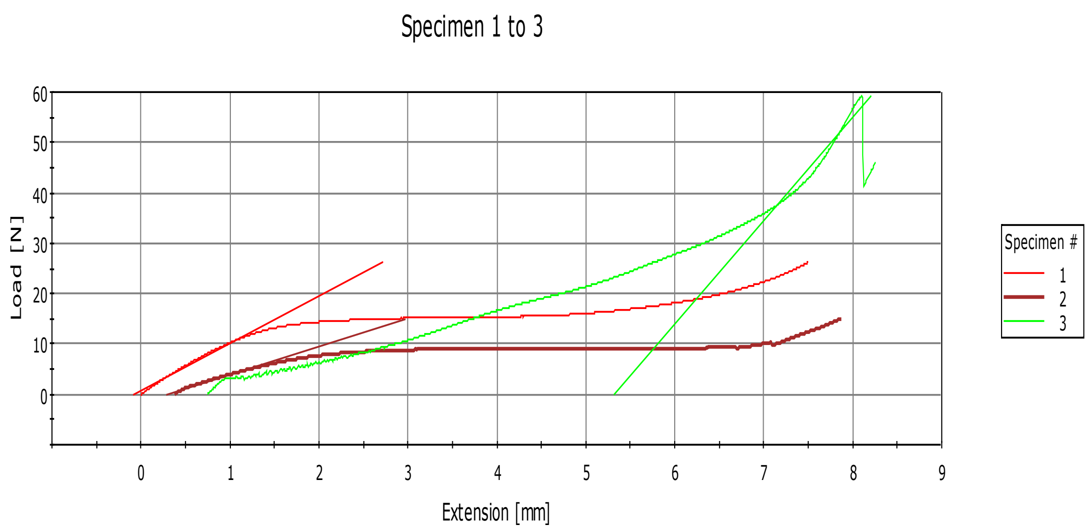

Figure 12: Load vs. Extension from 3 point bend testing