Proposed Method for Shear Modulus Determination from Picture-Frame Test Data

Figure 1: Picture-frame test apparatus (UML)

To determine the shear modulus of a given fabric from data obtained using the picture-frame test, begin with normalized force data. Both Peng et al. [2004] and Harrison et al. [2004] have developed normalization methods using an energy method. Harrison et al. [2004] studied the case where the frame length is equal to the fabric length. They researched and proposed a method for comparing the force results obtained using shear frames (and as a result fabric samples) of different sizes. Peng et al. [2004] studied that case and the case where the length of the fabric sample is not equal to the length of the frame. Their equation reduces to the method proposed by Harrison et al. [2004] for the case when the fabric length is equal to the frame length.

As proposed by Peng et al. [2004], to normalize the force data,

\[ P_{\text{normalized}} = P_{\text{original}} \cdot \frac{L_{\text{frame}}}{L_{\text{fabric}}} \]  \hspace{1cm} \text{Eq. 1}

When the length of the fabric is equal to the length of the frame, this equation becomes,

\[ P_{\text{normalized}} = P_{\text{original}} \cdot \frac{1}{L_{\text{frame}}} = P_{\text{original}} \cdot \frac{1}{L_{\text{fabric}}} \]  \hspace{1cm} \text{Eq. 2}

as proposed by Harrison et al. [2004].
By definition, the shear stress is obtained by dividing force by area.

\[ \tau = \frac{P_{\text{original}}}{\text{Area}} = \frac{P_{\text{original}}}{L_{\text{fabric}} \cdot t_{\text{fabric}}} \]  

Eq. 3

Also, by definition the cross-sectional area is equal to the length of the fabric multiplied by the thickness of the fabric. Note that the denominator in Eq. 3 contains \( L_{\text{fabric}} \), as does the denominator of the normalized force in Eqs. 1 and 2. Thus, to calculate the shear stress using the normalized force, it is only necessary to divide the normalized force by the thickness not the area. Hence, the shear stress is,

\[ \tau = \frac{P_{\text{normalized}}}{t_{\text{fabric}}} \]  

Eq. 4

It is then proposed that the shear modulus can be calculated from the derivative of the regression equation determined from the data points on the shear stress versus shear strain plot, if the units of shear strain are in radians.

References:
