Mapping Design Parameters of Foam Composites in Midsoles

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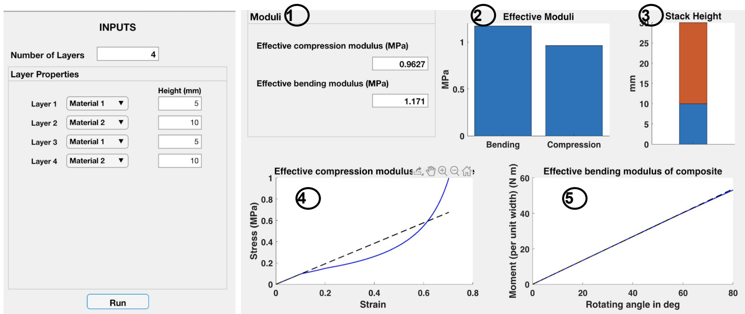
Adidas has launched an effort to tailor performance footwear to individual physiological data and preferences. To create differences in behavior, performance, and comfort, different materials are used for a shoe midsole, thereby altering mechanical properties such as bending stiffness and compression.

Current shoe design practice does not specifically consider the mechanical properties of midsoles. **Our team developed a model to predict and map the design parameters of composite midsoles in order to effectively predict mechanical behavior and better understand the connection to performance.** Next steps are to experimentally verify and adjust the predictive model and integrate the two user interfaces into one platform for designer convenience.

Integrated User Interfaces

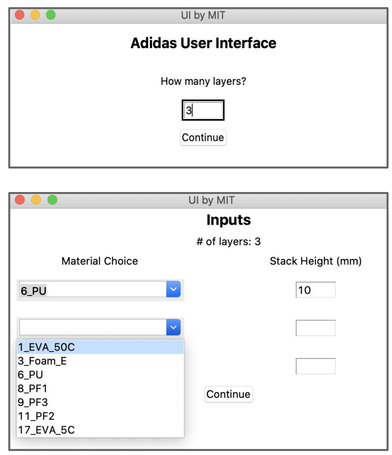
MATLAB App

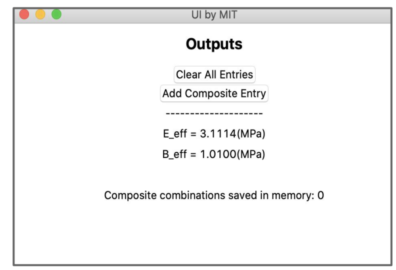


Immediately, the following outputs will populate.

1. Calculated numerical moduli
2. Graphical comparison of moduli
3. Composite material breakdown
4. Stress-strain plot used to derive compression modulus
5. Moment-angle plot used to derive bending modulus

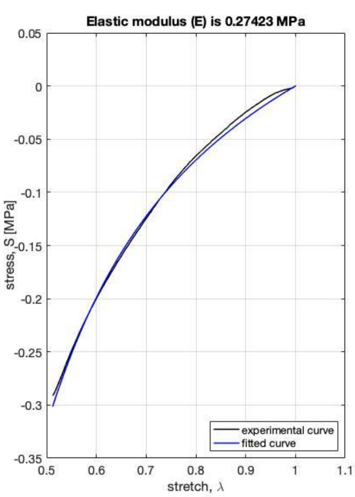
Python App





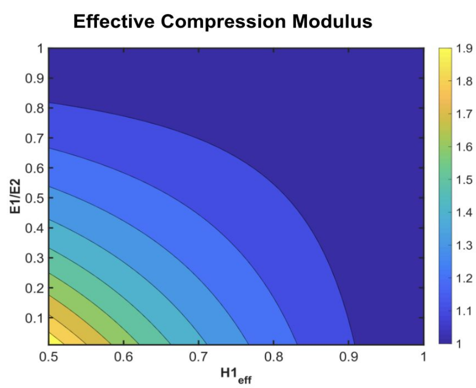
To test multiple designs, the user can add numerous inputs and compare the moduli of each.

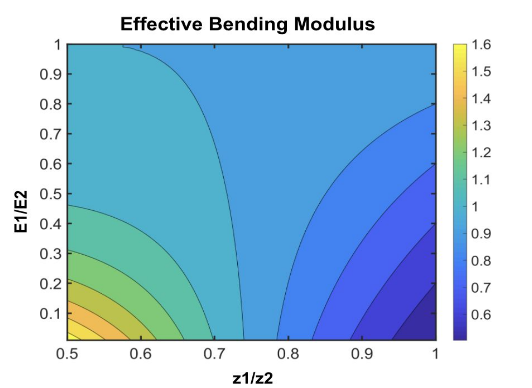
Materials Characterization

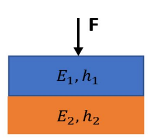


Fitting experimental data revealed that the **Neo-Hookean model** was a sufficient model to **extract the material properties** from stress and stretch. An example fit for PF_2 is shown above.

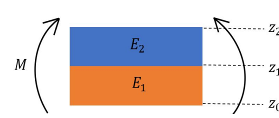
Bending & Compression Modeling







$$\widehat{E_{eff}} = \frac{E_{eff}}{E_1},\ h_1^{eff} = \frac{h_1}{h_{total}},$$
$$h_2^{eff} = \frac{h_2}{h_{total}},\ E_R = \frac{E_1}{E_2}$$



$$z_c = \frac{\sum_{i=1}^{n} E_i(z_i^2 - z_{i-1}^2)}{2\sum_{i=1}^{n} E_i(z_i - z_{i-1})}$$

$$E_{eff} = \frac{1}{\sum_{i=1}^{n} \frac{h_i}{h} \times \frac{1}{E_i}}$$

$$B_{eff} = 4\sum_{i=1}^{n} E_i\left[\left(\frac{z_i}{z_n} - \frac{z_c}{z_n}\right)^3 - \left(\frac{z_{i-1}}{z_n} - \frac{z_c}{z_n}\right)^3\right]$$

The derived relations for effective moduli reveal a key dependence on both stack height ratio and material ratio that varies depending on the physical regime. The contour plots can serve as a tool for **choosing an optimal combination of two materials and stack heights given a desired effective modulus.**