Prediction of interface debonding in cord-rubber composites

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Introduction & formulation

A constitutive case study of **interface** have been performed using finite element tool. An elasto-plastic constitutive model is considered for the interface region and **indentation test** suggested in literature [1] has been simulated.

$$\epsilon = \epsilon^e + \epsilon^p \tag{1}$$

$$\dot{\epsilon} = \dot{\epsilon}^e + \dot{\epsilon}^p \tag{2}$$

A free energy function $\psi(\epsilon, \epsilon^p)$ is assumed to be a function of ϵ, ϵ^p. Considering Clausius-Duhem inequality the constitutive equation for stress becomes

$$\sigma = \bar{\rho}\frac{\partial \psi}{\partial \epsilon^e} \tag{3}$$

For this constitutive model, **von-Mises** type of yield model is considered, which can be expressed as

$$\Phi(\sigma, \sigma_y) = \sqrt{3J_2(s(\sigma))} - \sigma_y \tag{4}$$

Numerical model & Preprocessing

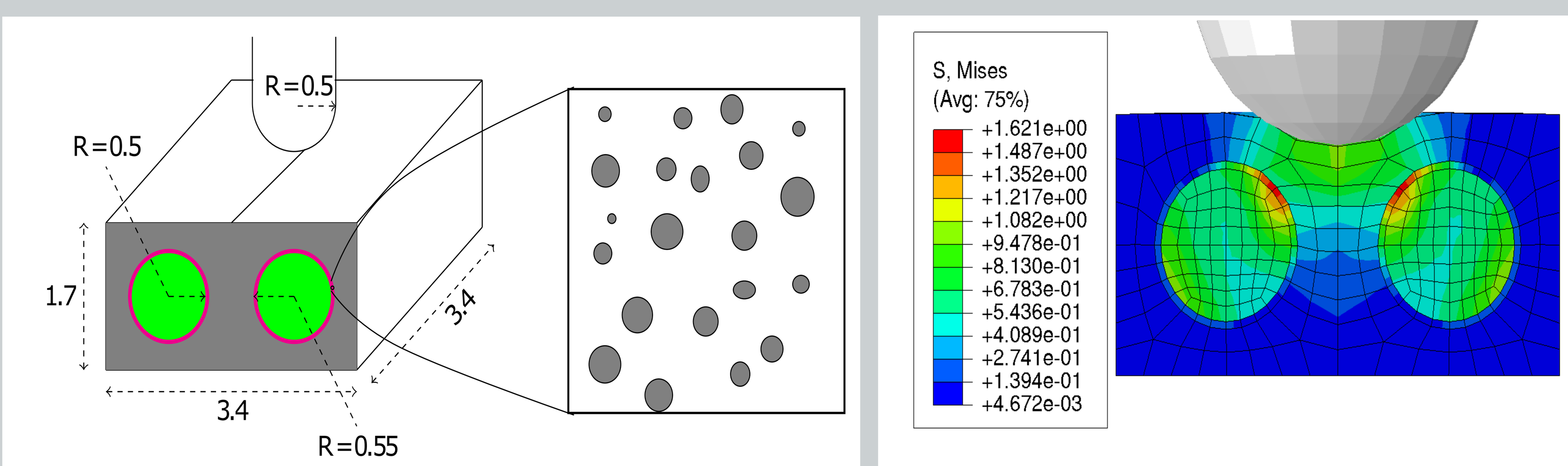

Fig. 1: Numerical model [1] and Microscopic view of interface [2] (left) and von-Mises stress distribution in the model (right)

For von-Mises stress criteria yield stress is required. Hence, for each elastic modulus, yield stresses are obtained considering three different strain energy cases.

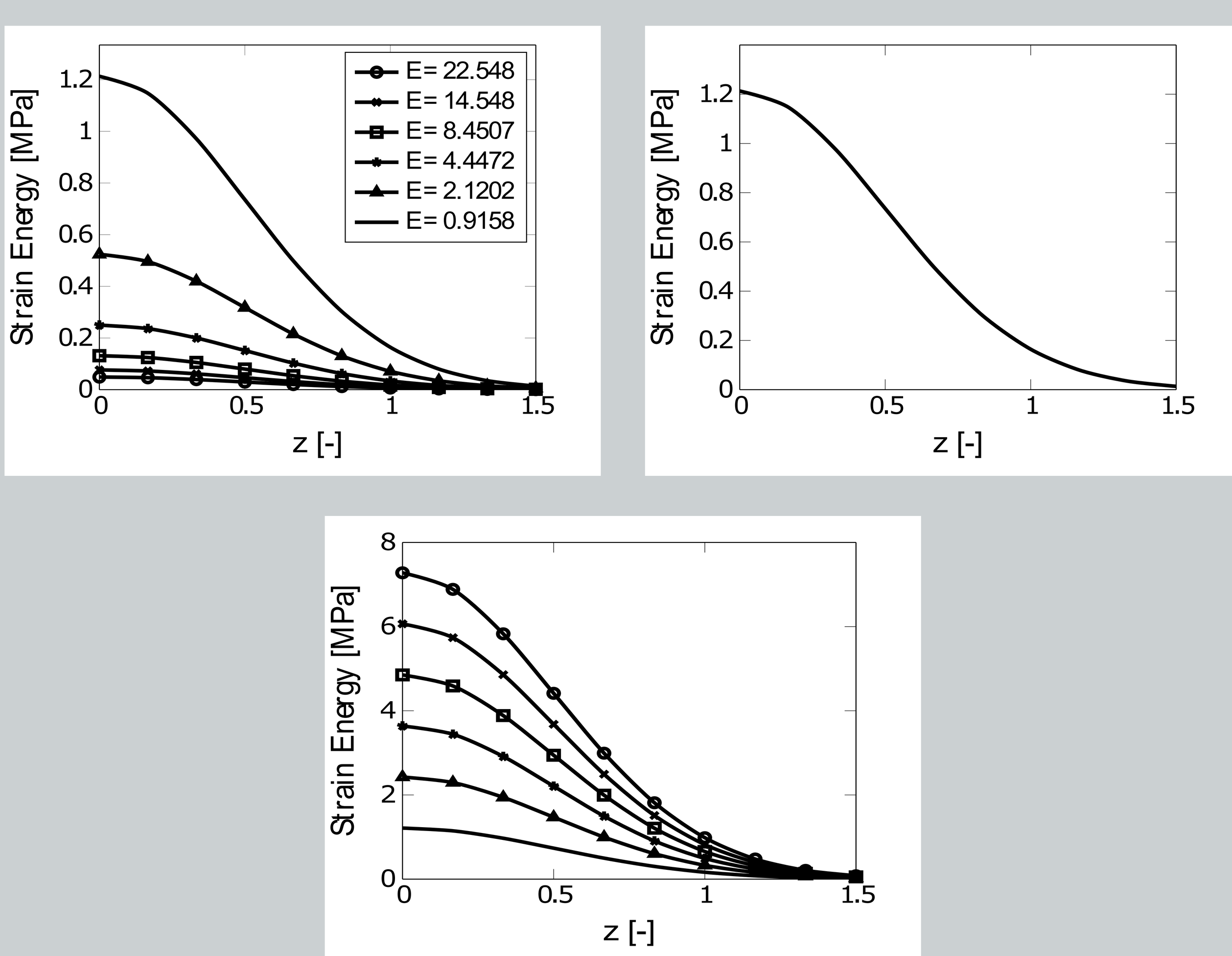

Fig. 2: Strain Energy for three cases

Computational Results

Case 1 - Strain energy is more for low elastic modulus

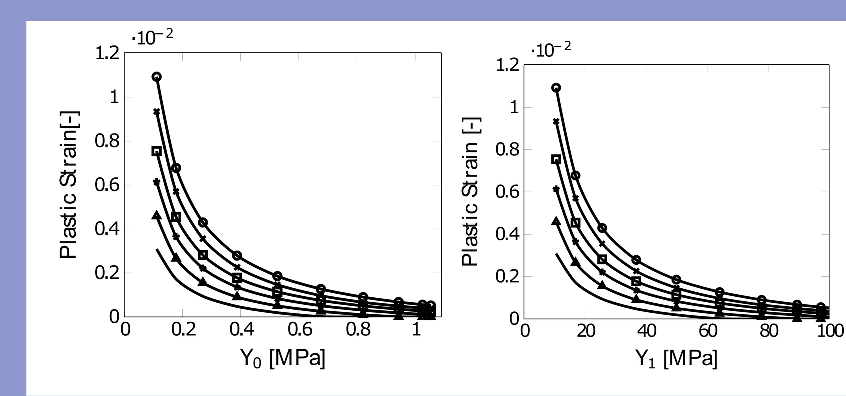

Fig. 3: Variation of plastic strain w.r.t. yield stress

Case 2 - Strain energy is same for all elastic modulus.

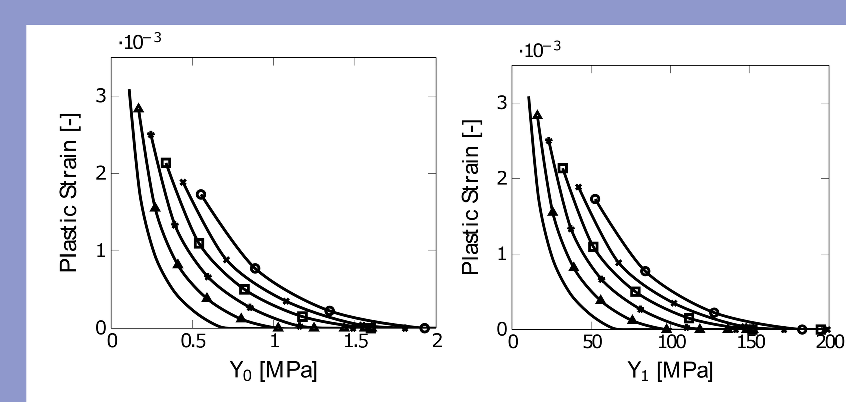

Fig. 4: Variation of plastic strain w.r.t. yield stress

Case 3 - Strain energy is more for higher elastic modulus.

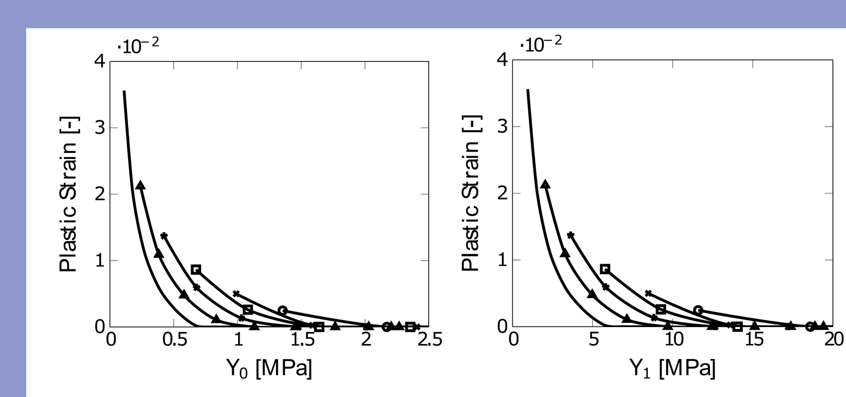

Fig. 5: Variation of plastic strain w.r.t. yield stress

Discussion & Outlook

Keeping **yield stress** same for all elastic modulus, the **plastic strain** developed should be more for higher elastic modulus, that is the result obtained from case 1. While if yield stress is reduced for lower elastic modulus to keep **elastic strain energy** constant, the plastic strain produced should be more, which is evident by considering its analogy with uni-axial elasto-plastic constitutive model. That's what is happening in case 2. If yield stress is decreased below that, as in case 3, the trend for plastic strain remains same whereas the magnitude increases. These results are completely in agreement with the theory. Hence the combination of **elastic modulus** and yield stress producing very less plastic strain in the interface in all cases can be considered for further simulations.

References / Publications

[1]Valantin, C., et al.(2015), Interfacial damage on fatigue-loaded textile-rubber composites.

[2]Morteza Sadat Shirazi (2012), Aromatic Polyamide Short Fibres-Reinforced Elastomers: Adhesion Mechanisms and the Composite's Performance Properties.

» This project is supported by German Academic Exchange Service (DAAD). «

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