USING DATA FROM MULTIPLE TESTS TO DETERMINE FOAM PARAMETERS: MODELING IMPLICATIONS

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INTRODUCTION

Elastomeric foams are represented in finite element (FE) models using constitutive equations containing one or more material specific parameters. Previous work has suggested that the test data used in material parameter determination may have a large effect on simulation results [1]. Specifically, parameters for simulations involving multi-mode deformations should be determined from test data describing all simulated deformation modes. The practical implications of multi-test parameter determination have not been shown in a FE simulation for footwear applications.

This investigation illustrates the effects of using data from multiple tests for foam parameter determination on predictions of clinical interest by simulating the indention of a foam mat by the human heel pad.

METHODS

Two sets of Poron® foam parameters for a common compressible hyperelastic model [2] were determined using custom Matlab® optimization scripts. One parameter set was determined from uni-axial compression data alone and the other from a combination of uni-axial compression, simple shear, and volumetric compression data. The material parameters were incorporated into a pre-existing hyperfoam material model inherent in ABAQUS® FE software.

A plane-strain heel pad model described elsewhere in detail [3] was used to indent a 10mm thick foam mat (Figure 1). The simulation was run twice, once with each set of material parameters. Peak normal stress (plantar pressure) and shear stress were extracted.

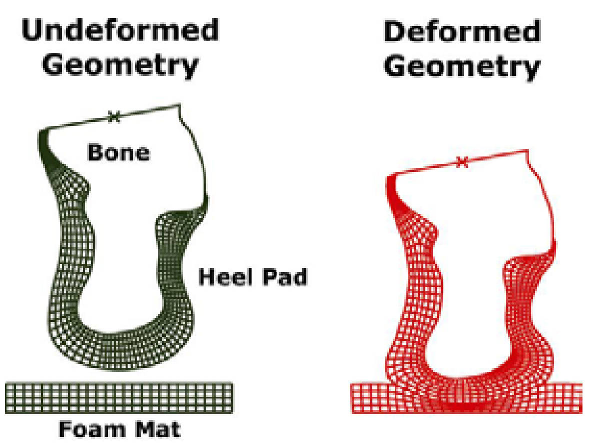

Figure 1. The undeformed and deformed heel pad indentation model. Final geometry was similar for both parameter sets.

RESULTS AND DISCUSSION

Fitting parameters to compression data alone led to high errors in material model prediction of the shear and volumetric test data. Simultaneous fitting of all three deformation modes provided reasonable predictions (RMS error < 5% of maximum) of all test data (Table 2).

Test Data Used in	Order	Errors (RMS as a % of maximum)		
		Uni-axial Compression	Simple Shear	Volumetric Compression
Uni-axial Compression	1	0.67	1.34×10^6	58.5
Compression, Shear, Volumetric	3	4.24	1.30	2.04

Table 1. Material model errors for the two sets of Poron® parameters.

Although the heel pad simulation involves a strictly compressive load, non-linear geometry and friction lead to the generation of multi-axial deformation. When different test data sets were used in parameter determination, large differences between predicted peak stresses were present (Table 2).

Test Data Used in Parameter Determination	Order	Peak Pressure (kPa)	Peak Shear Stress (kPa)
Uni-axial Compression	1	288	62
Compression, Shear, Volumetric	3	258	36

Table 2. Simulation predictions of peak stresses vary with the amount of data used in parameter determination.

Parameters determined from compression alone can not accurately predict shear behavior, leading to an over estimation of about 72%. There is also a discrepancy in the peak pressure prediction that could be due to extrapolation error because the simulation strain has exceeded the maximum strain supplied in the test data.

REFERENCES

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