EN2210 Continuum Mechanics

Project

Measuring the constitutive behavior of elastomeric sheets

Synopsis

You will design and construct a simple apparatus to subject an elastomeric sheet specimen to prescribed loads. You will use your equipment to determine the uniaxial and biaxial response of a sample, and fit the data with a hyperelastic constitutive equation of your choosing.

1. Introduction

While most of the governing equations in continuum mechanics are invariable physical laws, the constitutive law for the solid or fluid of interest must always be determined and calibrated experimentally. Measuring the response of a material to prescribed loading is thus a standard problem in solid and fluid mechanics.

In this project, you will design and construct a simple apparatus to measure (approximately) the response of a thin elastomeric sheet to uniaxial and biaxial loading. You will use your equipment to select and calibrate a constitutive model that fits your data.

Your apparatus should be home-made and constructed from readily available materials, rather than making use of sophisticated equipment that you borrow from your lab!

You will need to devise some way to apply prescribed forces to the specimen, and measure the resulting deformation.

A few basic materials, hand-tools and supplies will be provided for you to work with. You can use other equipment and materials if you wish, but please acquire them legally… Use of facilities such as JEPIS, rapid prototyping, research engineer/technician help, or outsourcing to developing countries is not allowed!

Some questions you might try to answer include

1. Is the material incompressible (or close to it?)
2. Is the material isotropic?
3. What is its uniaxial and biaxial response?
4. Which hyperelastic potential gives the best fit to the measured data? What parameters yield the best fit?

The project may be done individually, or in groups of up to 3 people.

2. Project Deliverables:

Your mission is to provide:

1. An apparatus that is capable of measuring the constitutive behavior of elastomeric sheets
2. A short report (2 pages, one report per group) describing the constitutive law that you selected to model the material; giving values for relevant material properties, and comparing measured and predicted behavior (with an estimate of errors).
3. A 10 min oral presentation that demonstrates your design and reports the results of your measurements.
4. A peer evaluation of the contributions of group members to the project (completed on test day)

The due date for both is **Monday December 10.** Presentations will be given in class (and will continue into the following class hour).

You can be entertaining and innovative in your presentations (just to ensure that there is finally one interesting class in the course). Your presentations could feature verse, cuddly animals, or magic tricks involving rubber. We will take votes for 'best presentation' 'best experimental apparatus' and 'most exciting hyperelastic constitutive law'

Appendix 1: Grading Rubric

1. Design of experimental apparatus – 10 points.
   - Well built, robust and easy to use design that gives accurate and repeatable data
2. Report – 10 points
   - Clearly written description of experimental data; compared to predictions of various constitutive models
3. Presentation – 10 points
   - Articulate, well organized and correctly timed presentation that includes relevant data and results, with contributions from all group members.
4. Peer evaluation – 5 points

Appendix 2: Materials and tools

The catalog numbers are from McMaster-Carr (so you can find details of all the supplies on the web)

Tools (one of each per group)

Ultra economy plastic electronic calipers 4996A21
Hacksaw 4077A1
Electric drill
Razor blades
Flathead screwdriver

Materials

Latex rubber dental dams (specimens)	
1'x1' marine grade plywood board 1125T21	1 per group
Acrylic bars, 4' length, 1/8" thick, 1" wide 1227T119	1 per group
Acrylic bars, 4' length, 3/16" thick 1" wide 1227T819	1 per group
Acrylic bars, 4' length, 1/2" thick 1" wide 1227T419	1 per group
Clear PVC unthreaded pipe, 4ft length, 0.344" ID, ¼" OD, 49035K21	1 per group
Clear PVC unthreaded pipe, 4ft length, 0.602" ID, ¾" OD, 49035K23	1 per group
36" long 1/8" diameter birch dowell rod 9683K11	1 per group
36" long ¼" diameter birch dowell rod 9683K13	1 per group
Extra strength braided polyester twine, 0.033" dia, 50lb breaking strain, 8936T41	3 total
Light force iron C clamp, 3" opening, 2" depth, 800lb holding cap, 5133A15	4 per group
½" steel binder clips, ¼" jaw opening, 12 per box, 12755T71	2 box/group
Pulley blocks 3742T53	4 per group
Mounted pulleys 11/16 OD 3071T21	2 per group
Machine screw assortment 6-32 thread, 1/2", 1" 1 1/2" 2" 3"	In stock
Machine screw 6-32 wing nuts 98671A110	In stock
¼" Eye bolts	In stock