Lab Manual for Engrd 202, Virtual Torsion Experiment

(Turkey tibiotarsus)

Introduction

In this module, you will perform data reduction and analysis for turkey tibiotarsus bones. They are not circular in cross section and so the analysis for bones is different from the circular samples. In the analysis, you will approximate the bone as a hollow circular cross section. You will use the dimensions of the circular cross section to estimate the stiffness, shear modulus and strength of the bone.

You will plot the torque vs. twist curve and study it to examine the behavior of bone under torsional loading. From this plot you will determine whole bone ultimate torque and stiffness. Based on these values, you will deduce bone material properties such as shear strength and shear modulus. You may note that each individual bone behaves slightly different. Details of the sample geometry, as defined in slides 6 and 7 of the chalk talk on turkey bone, are provided along with each data file. For review refer to the chalk talk on turkey bone. To understand the calculations for cross sectional area and polar moment of inertia, refer to slide 7 of the chalk talk on turkey bone.

Procedure

Select one data set from the wet turkey bone test data and one from the dry turkey bone test data. The measured dimensions for each bone sample are listed at the top of the text and Excel data files. This information is displayed in the Matlab GUI as well. Date files are named according to the following convention: Material_Type_Repeat.***, where the stars are in place of the file type extension. For example turkeybone_Wet_3.xls would be the Excel file containing data for the test performed on wet turkey sample 3. Plot the torque-twist curves for the data set; continue your analysis by completing tables 3 and 4, then proceed to answering the questions below and to writing your lab report. Step-by-step directions for completing the data sheets, (tables 3 and 4) are given at the end of the module.

Lab Report

Your lab report should include the completed data sheets, graphs and a brief discussion of the lab procedure. The report should also provide answers to the questions below and any other discussion, observations or comments you wish to include.

Questions and data analysis for turkey tibiotarsus:

1. Find the shear modulus, G, and the shear strength, τ_u .
2. Using your textbooks and other resources, find a different material (or materials) with similar G values to the wet turkey bone. Do you think that this material can be used as an artificial bone?
3. Describe in words what the fracture surfaces look like. Do all the bones break exactly in the same way?
4. Suppose you want to breed super turkeys that were twice the mass of normal turkeys. Do you think the tibiotarsus bone would be thicker and or bigger in diameter ($2r_0$)? If so, by how much would these increase to double the torsional load carrying capacity of the wet bone?
5. Compare the results you got for the dry turkey bone to those for the wet turkey bone. How do the ultimate torque T_u , the bone stiffness, the shear modulus and shear strength differ?

Step by step instructions for completing Tables 3 and 4 for a given sample ID

a) Select the data file and open it. You may choose to use a text file (.txt) or an Excel file (.xls). The Matlab GUI (VL_1_v10.m) uses the .txt files.

b) Enter the sample ID, material and the dimensions of the test sample on table 3. Use the information given in the header of the text file or Excel file. If you choose to use the Matlab program, this information will be displayed on the GUI.

c) Calculate the area and polar moment of inertia of the equivalent circular cross section. Refer to slides 6 and 7 of the chalk talk on turkey bone for details. Enter these values in rows 2 and 3 of table 4.

d) Plot the torque vs. twist for the sample. For this purpose, you may choose to use the Matlab GUI. In the Excel files the plots are provided to you. You may refer to 'Hints for graphing' in case of any difficulty in plotting the data.

e) From the plot, find the ultimate torque T_u. Fill this value in row 4, table 4.

f) Now, plot the torque-twist curve in the linear region. Find the sample stiffness (equal to the slope of the line). Denote this value as k_{total} , the total stiffness (slide 8 of the chalk

talk on turkey bone). Note that you may assume $k_{total} = k_{sample}$, since the test machine is almost infinitely stiffer than the bone sample. Enter this value in row 5, table 4.

g) Now using formulas given in slides 9 and 10 of the chalk talk on turkey bone, calculate the shear modulus and shear strength for the bone. Enter these values in rows 6 and 7 of table 4.