ME556 LAB EXPERIMENT

ANALYSIS OF A U-SHAPED BEAM SUBJECTED TO TENSILE LOADINGS

LAB REPORT DUE ON TUESDAY NOVEMBER 21

Objective: To measure strains induced in a U-shaped beam using strain gages, and to compare these measurements with the analytical solution.

General Description: The U-shaped beam is shown schematically in Figure 1. The specimen is made of 7075-T6 aluminum (assume $E = 10.4 \times 10^6$ psi, $\nu = 0.32$). As indicated, five (5) stacked rectangular rosettes (M-M type WA-13-060WR-120) have been bonded along the radial line defined by $\theta = 30^\circ$.

The rosettes will be referred to as rosettes A, B, C, D, and E. Since each rosette consists of three gage elements, a total of fifteen (15) individual strain gages are involved. The radial position of each rosette as well as gage numbers are defined in Figure 2. The gage factor and transverse sensitivity for all gage elements are: $S_g = 2.15$, $K_t = +0.9\%$.

Download the "Official Data" (to be used during data reduction) from the course website. Collect your own data using the following procedures:

Testing Procedures: Detailed instructions for conducting the tests are presented in the lab video entitled "Curved Beam Lab", available on the course website and on the desktop of the computer located in MEB 123. Briefly, the U-shaped beam will be subjected to tensile loadings using the Instron Model 8511 hydraulic test frame. Both the Instron load cell and the 15 individual strain gage elements are wired into separate Wheatstone bridge circuits. The load cell utilizes a full-bridge circuit, whereas the strain gages are monitored using ¼ -bridge circuits. Output from all 16 circuits, as well as the position of the hydraulic cylinder, are monitored using the StrainSmart software package. The StrainSmart software has been set up to correct for transverse sensitivity effects automatically, so the strains recorded can be used without any additional corrections.

Data Reduction Procedures (USE THE OFFICIAL DATA IN THE FOLLOWING):

1) Assume measured strains are linearly related to load P according to the general form $\varepsilon_i = m_i(P) + b_i$, where i = gage number. Determine m_i and b_i for each gage using linear regression, and record each value on the attached data sheet. Linear regression can be performed using built-in functions in commercial software packages (e.g., the linest(y,x) function, or the slope(y,x) and intercept(y,x) functions in Excel), or through the use of Eq 20.33 in the course textbook.

2) Using the results of step (1), calculate "experimental" expressions relating the principal strains (ε_1 and ε_2) to applied load P at each rosette site [$\varepsilon_1 = m_{\varepsilon 1}(P)$ and $\varepsilon_2 = m_{\varepsilon 2}(P)$, say]. These will be called "measured" values. Record the measured values of $m_{\varepsilon 1}$, $m_{\varepsilon 2}$ on the attached ME 556 CURVED BEAM DATA SHEET.

3) Based on the elasticity solution, calculate "predicted" expressions relating the principal strains (ε_1 and ε_2) to applied load at each rosette site [$\varepsilon_1 = m_{\varepsilon 1}(P)$ and $\varepsilon_2 = m_{\varepsilon 2}(P)$, say]. Record predicted values of $m_{\varepsilon 1}$, $m_{\varepsilon 2}$ on the attached ME 556 CURVED BEAM DATA SHEET.

4) Using the results of step (2) and Hooke's law, calculate "experimental" expressions relating principal stresses (σ_1 and σ_2) to applied load at each rosette site [$\sigma_1 = m_{\sigma 1}(P)$ and $\sigma_2 = m_{\sigma 2}(P)$, say]. Record measured values of $m_{\sigma 1}$, $m_{\sigma 2}$ on the attached ME 556 CURVED BEAM DATA SHEET.

5) Using the results of step (3) and Hooke's law, calculate "predicted" expressions relating principal stresses (σ_1 and σ_2) to applied load at each rosette site [$\sigma_1 = m_{\sigma 1}(P)$ and $\sigma_2 = m_{\sigma 2}(P)$, say]. Record predicted values of $m_{\sigma 1}$, $m_{\sigma 2}$ on the attached ME 556 CURVED BEAM DATA SHEET.

6) Using the results of steps (2-5), calculate both the measured and predicted orientation of the +1-axis at each rosette sites, with respect to the line of action of the applied load P. Record measured and predicted orientation angles on the ME 556 CURVED BEAM DATA SHEET.

Lab Report

Prepare a brief report describing the lab. Include a plot of predicted and measured principal stresses and orientation angles versus radial position (i.e., a plot(s) similar to that prepared for the corresponding homework assignment). Include an appendix that includes (at minimum):

- a plot or plots that compare the data you collect with the "Official" data downloaded from the class website
- a completed "ME 556 CURVED BEAM DATA SHEET" , as described above

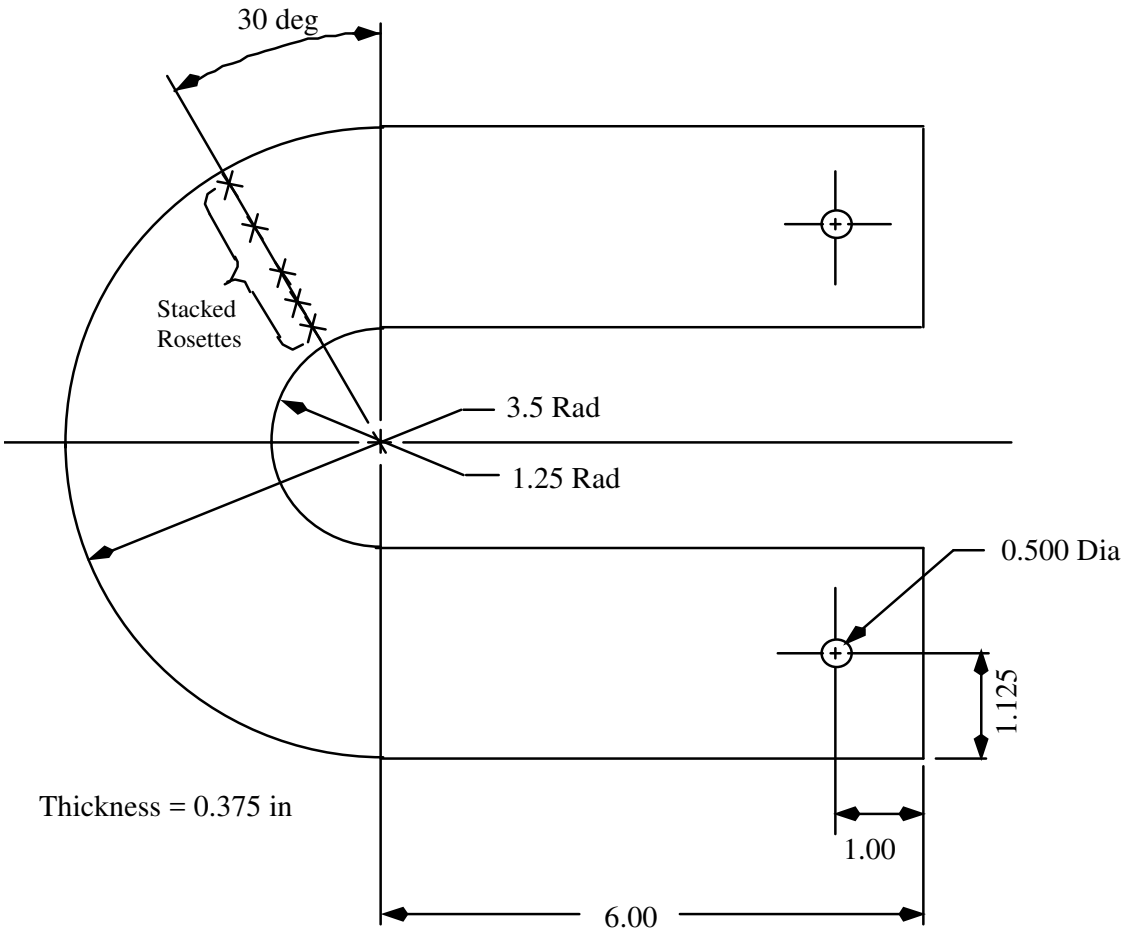
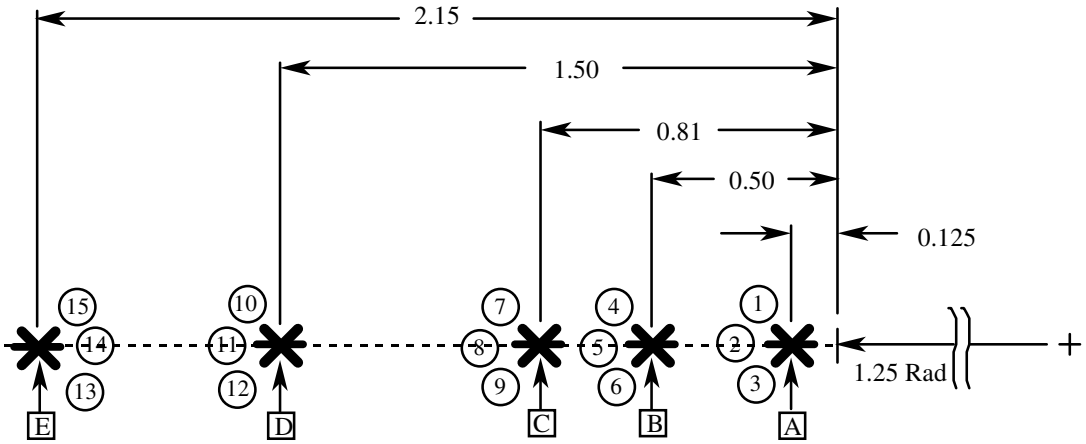


Figure 1: Specimen dimensions and orientation of the strain-gaged radial line (all dimensions in inches)



Note: Rosettes A, C, and E are on one side of the specimen, while rosettes B and D are on the opposite side

Figure 2: Rosette radial locations, gage numbers, and gage orientation (all dimensions in inches)

ME 556 CURVED BEAM DATA SHEET

1. Linear regression of original data:

Rosette	Gage Number	m (μin/in/lb_f)	b (μin/in)
A	1		
	2		
	3		
B	4		
	5		
	6		
C	7		
	8		
	9		
D	10		
	11		
	12		
E	13		
	14		
	15		

2. Principal strains:

	Measured		Predicted	
Rosette	Principal Strains and Orientation Angle	$m_{\varepsilon 1}$, $m_{\varepsilon 2}$, or θ (μin/in/lb_f or degs)	Principal Strains	$m_{\varepsilon 1}$, $m_{\varepsilon 2}$, or θ (μin/in/lb_f or degs)
A	ε_1		ε_1	
	ε_2		ε_2	
	θ		θ	
B	ε_1		ε_1	
	ε_2		ε_2	
	θ		θ	
C	ε_1		ε_1	
	ε_2		ε_2	
	θ		θ	
D	ε_1		ε_1	
	ε_2		ε_2	
	θ		θ	
E	ε_1		ε_1	
	ε_2		ε_2	
	θ		θ	

3. Principal stresses:

	Measured		Predicted	
Rosette	Principal Stresses and Orientation Angle	$m_{\sigma 1}$, $m_{\sigma 2}$, or θ (psi/lb_f or degs)	Principal Stresses	$m_{\sigma 1}$, $m_{\sigma 2}$, or θ (psi/lb_f or degs)
A	σ_1		σ_1	
	σ_2		σ_2	
	θ		θ	
B	σ_1		σ_1	
	σ_2		σ_2	
	θ		θ	
C	σ_1		σ_1	
	σ_2		σ_2	
	θ		θ	
D	σ_1		σ_1	
	σ_2		σ_2	
	θ		θ	
E	σ_1		σ_1	
	σ_2		σ_2	
	θ		θ	