ME 457 Experimental Solid Mechanics (Lab)

Curved Bars Experiment

Introduction :

Though curved bars are not commonly found as structures by themselves, they are usually part of a mechanical member which has a combination of straight and curved elements. The study of how curved bars deflect is thus, important so as to estimate the total mechanical displacement of structures that incorporate curved sections. One of the more effective methods used to estimate deflections in curved bars comes from Castigliano's first theorem or from a unit-load method. This experiment puts the unit-load approach to the test. The test apparatus will demonstrate the actual behavior of curved bars set up in different configurations and comparisons will be made to the unit-load method's results. Sometimes, due to the complex nature of the integral involved, an approximate method such as Simpson's Rule can be used instead of an analytical integration.

Apparatuses :

1. Curved bar apparatus
2. Load hangers and 'C' hook
3. Dial gauges
4. Wrench
5. Weight set

Procedure :

Ring Experiment :

1. For the ring configuration, hang the 'C' hook from the bottom of the ring and attach the load hanger to it. The vertical dial is permanently set in its position while the right and left dials can be removed and used in the other experiments.
2. Zero all three dials and read the initial zero-datum reading off them.
3. Next, load the ring by increments of 5 N, up to 40 N. At each increment record the deflection at each dial and tabulate these in a table such as the one below :

Load (N)	Vertical		Horizontal				
	Dial Rdg. (mm)	Deflec. (mm)	Dial Rdg. Left (mm)	Defleciton Left (mm)	Dial Rdg. Right(mm)	Deflection Right(mm)	Total Horizontal

4. Subtract your zero-datum reading from all your readings to get your actual deflections.

Quadrant Experiment :

1. First, attach the hanger onto the quadrant and apply a 2 N weight on it. This is to stabilize the system and will not be counted as part of the weight that we will apply onto it.

2. Secure the removable dials onto the quadrant experiment setup to measure horizontal and vertical displacements of the curved (quadrant) member.
3. Zero the two dials and record the zero-datum reading.
4. Load the member with weight increments of 2 N up to 14 N. At each increment record your results on a table such as this one :

Load (N)	Vertical		Horizontal	
	Dial Rdg. (mm)	Deflection (mm)	Dial Rdg. (mm)	Deflection (mm)

5. Similarly, subtract the zero datum-reading from the actual readings to obtain the deflections.

Semi-circle experiment :

1. Attach the hanger onto the semi-circle and apply a 2 N weight on it. This will stabilize the system and does not count as part of the weight that we will apply onto it.
2. Secure the removable dials onto the semi-circle experiment setup to measure horizontal and vertical displacements.
3. Zero the two dials and record the zero-datum reading.
4. Load the member with weight increments of 2 N up to 14 N. At each increment record your results on a table such as this one :

Load (N)	Vertical		Horizontal	
	Dial Rdg. (mm)	Deflection (mm)	Dial Rdg. (mm)	Deflection (mm)

5. Again, subtract the zero datum-reading from the actual readings to obtain the deflections.

<u>Analysis :</u>

All three members are made from 25 × 3 mm steel strips with a Young's modulus of E = 205 GPa. The radii (or diameters) for each experiment is listed as follows:

Ring: 300 mm diameter
Quadrant: 150 mm radius
Semi-circle: 150 mm radius

1. For all three experiments (ring, quadrant and semi-circle) use the data points that you obtained and plot the load, P (ordinate) vs. deflection, δ (abscissa) as a straight-line curve fit for both horizontal and vertical components. Plot both these components on one graph. And since there are 3 experiments, 3 graphs are expected.
2. Using the table given below, find the exact and the approximate deflections for the tested members as follows :
   a) For the ring at a load of 20 N.

b) For the quadrant at a load of 8 N.
c) For the semi-circle at a load of 8 N.

Member	Vertical Defn.		Horizontal Defn.	
	Exact	Approx.	Exact	Approx.
Semicircle	$\frac{\pi PR^3}{2EI}$	$\frac{\pi PR^3}{2EI}$	$\frac{2PR^3}{EI}$	$\frac{2PR^3}{EI}$
Quadrant	$\frac{\pi PR^3}{4EI}$	$\frac{\pi PR^3}{4EI}$	$\frac{0.5PR^3}{EI}$	$\frac{0.48PR^3}{EI}$
Davit	$\frac{\pi PR^3}{4EI} + \frac{PR^2L}{EI}$	both terms the same	$\frac{PR^3}{2EI} + \frac{PRL}{2EI}(2R+L)$	$\frac{0.48PR^3}{EI}$ + same 2nd term
Ring	$\frac{0.149PR^3}{EI}$	$\frac{0.148PR^3}{EI}$	$\frac{0.137PR^3}{EI}$	$\frac{0.114PR^3}{EI}$

3. Compare your approximate theoretical results with the deflections cross-referenced off your graphs in step 1. Provide the % error for each of these values. Comment on any differences between experimental and approximate analytical values (explain in detail the reasons why the experimental data varies from the analytical approximation).