Session #5 MECH 221 Solutions

1.11

$\sigma_y = 275\ MPa$ $\qquad A_0 = 325\,mm^2$

$E = 115\ GPa$

a) $\sigma_y = \frac{F_y}{A_0} \rightarrow F_y = \sigma_y A_0 = (275 * 10^6)(0.000325) = \underline{89375\ N}$

b) $l_0 = 115\ mm$ $\qquad \sigma_y = E\varepsilon_y$ $\qquad \varepsilon_y = \frac{\sigma_y}{E} = \frac{275 * 10^6}{115 * 10^9} = 0.00239$

$\varepsilon = \frac{l_f - l_0}{l_0} = 0.00239 = \frac{l_f - 115}{115} \rightarrow l_f = \underline{115.275\ mm}$

2.11

Steel $\quad d_0 = 10mm \qquad d_f = 10 - 0.003 = 9.997mm$

$\varepsilon_x = \frac{d_f - d_0}{d_0} = \frac{9.997 - 10}{10} = -0.0003$

$\nu = -\frac{\varepsilon_x}{\varepsilon_z} = 0.3 = \frac{0.0003}{\varepsilon_z} \rightarrow \varepsilon_z = 0.001$

$\frac{F}{A_0} = \sigma = E\varepsilon_z$

$F = A_0 E \varepsilon_z = \frac{\pi}{4} 0.01^2 (207 * 10^9)(0.001) = \underline{16250\ N}$

ENGR 244 (Mechanics of Materials)

Lab No. 5: DEFLECTION OF BEAMS

DATA SHEET

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Dimensions	BRASS	STEEL	ALUMINUM
Span Length, L (mm)	455	455	455
Width, w (mm)	19.10	19.22	19.28
Height, h (mm)	12.75	12.77	13.10

DEFLECTION OF BEAM, δ (mm)						
Applied Load	BRASS		STEEL		ALUMINUM	
	at x = L/2	at x = L/4	at x = L/2	at x = L/4	at x = L/2	at x = L/4
203 200 N	-1.67	-1.13	209 -0.68	-0.44	206 -1.90	-1.31
405 400 N	-3.20	-2.25	[illegible] -1.32	-0.91	402 -3.69	-3.51
600 N	-4.80	-3.39	603 -2.00	-1.39	606 -5.47	-3.77
806 800 N	-6.47	-4.50	803 -2.68	-1.87	808 -7.22	-4.98
1011 1000 N	-8.13	-5.67	1009 -3.38	-2.35	1005 -9.02	-6.29

PART 2

Beam Material: Brass, Beam width = 18.97 mm, height h= 3.92 mm

DEFLECTION OF BEAM, δ (mm)			
Applied Load		B) Cantilever Beam, L = 250 mm	
		at x = L	at x = L/2
100 gm		-1.37	-0.47
200 gm		-2.68	-0.91
300 gm		-3.85	-1.31
400 gm		-5.18	-1.76
500 gm		-6.41	-2.17

Analysis & Discussion: Follow the instructions given on page # 21 of your lab manual.

3.11 $d_0 = 12.8\,mm$ $d_f = 6.60\,mm$

$l_0 = 50.80\,mm$ $l_f = 72.14\,mm$

$$\%EL = 100\,\varepsilon_f = \frac{l_f - l_0}{l_0}100 = \frac{72.14 - 50.8}{50.8}100 = \underline{42\%}$$

$$\%RA = 100\frac{A_0 - A_f}{A_0} = \frac{\frac{\pi}{4}(12.8^2 - 6.6^2)}{\frac{\pi}{4}\,12.8^2}100 = \underline{73.4\%}$$

17.1 $l_0 = 300\,mm$ $A_0 = 4.5^2 = 20.25\,mm^2$

a) $\Delta l = 0.45\,mm \longrightarrow \varepsilon = \frac{0.45}{300} = 0.0015$

from figure, $\sigma = 300\,MPa$

$$F = \sigma A = (300 * 10^6)(2.025 * 10^{-5}) = \underline{6075\,N}$$

b) Zero. Within elastic region

18.1 $d_0 = 7.5\,mm$ $F = 6000\,N$

$l_0 = 90.0\,mm$

a) $\sigma = \frac{6000}{\frac{\pi}{4}0.0075^2} = 1.358 * 10^8\,Pa = 135.8\,MPa \longrightarrow$ (from figure) elastic $\varepsilon = 0.0015$

$$\varepsilon = 0.0015 = \frac{l_f - l_0}{l_0} = \frac{l_f - 90}{90} \longrightarrow l_f = \underline{90.135\,mm}$$

b) $F = 16500\,N$ $\sigma = \frac{16500}{\frac{\pi}{4}0.0075^2} = 3.735 * 10^8 = 373.5\,MPa \longrightarrow$ plastic $\varepsilon = 0.09$

after load release $\varepsilon = 0.085 = \frac{l_f - 90}{90} \longrightarrow l_f = \underline{97.65\,mm}$

The experimental deflections when compared to the theoretical values obtained by the theoretical equations were accurate in some cases and not very accurate in other situations. As mentioned earlier the accuracies varied depending on the material and the beam configuration. However, another possible reason that some of the experimental values did not match the values obtained using the theoretical equations could be due to the deflection measurements obtained by the deflection gauges. Perhaps some of the changes in deflection measurements were too small for the gauges to read, resulting in a larger percent error.

Referring to tables 12 and 13 below it can be seen that the elastic modulus of steel and aluminum for the simply supported beam are relatively accurate when compared to the published values. The simply supported brass beam on the other hand had a very large percent error for both the mid-span and quarter span, as well as in part B for the cantilever beam set up. In both the simply supported and cantilever beam position, brass had a percent error above 29%, however the simply supported set-up was more accurate. Therefore it can be concluded that the material being tested, the position where deflection readings are taken from and the beam configuration, all factor in the accuracy of the results. By looking at our results we have determined that a simply supported steel beam using the pump loading machine yielded the most accurate results. A simply supported aluminum beam yields the second most accurate results, and brass in both simply supported and the cantilever beam set-up yielded the least accurate results.

To see the actual experimental and theoretical elastic modulus values used to obtain the percent errors seen in tables 12 and 13 refer to tables 6 and 8 which can be found on pages 6 and 7.

Table#12: Percent Error of Elastic Modulus on Simply-Supported Beam (GPa)									
Position	Brass		%Error Brass	Steel		%Error Steel	Aluminum		%Error Aluminum
	Exp.	Theor.		Exp.	Theor.		Exp.	Theor.	
L/2	74.00	105.00	**29.52%**	177.92	200.00	**11.04%**	60.01	70.00	**14.27%**
L/4	73.34	105.00	**30.15%**	178.79	200.00	**10.61%**	56.39	70.00	**19.44%**

Table#13: Percent Error of Elastic Modulus on Cantilever Beam (GPa)			
Position	Brass		% Error Brass (Cantilever)
	Experimental	Theoretical	
L	73.72	105	**29.79%**
L/2	67.72	105	**35.50%**

Knowing how much certain materials will deflect depending on the load is extremely important, especially when constructing buildings. The material that deflects the least under greater loads is the best choice since it will reduce the chances of a building or structure from collapsing. By looking at figure 1 on page 6 we can see that steel deflects the least under the given loads when compared to brass and aluminum. Therefore steel would be the best material of the three materials tested to form the structure of a building.

Conclusion and Discussion:

5/5

By looking at the tables below we can see that the percent error of the deflections varies greatly by the material being tested and also vary slightly based on the location on the beam where the deflection readings were taken. By comparing the percent errors for the deflection of brass in part A and part B we can see the lowest percent error is 39.05% which is not very accurate. However, by comparing these percent errors we can observe that the values for the deflections are generally more accurate for brass on the simply-supported beam of part A than the cantilever beam of part B.

The deflections for steel and aluminum are more accurate as you can see in table #10, the percent errors for steel and aluminum are between 4% - 16%, which is fairly accurate when compared to brass. It is also worth mentioning that the percent errors for each material are greater at the quarter-span than at the mid-span of the beam. This could be due to the fact that a greater deflection occurs at the center of the beam than at the quarter-span, therefore a more accurate reading of the actual deflection of the beam due to the load is acquired. It can therefore be stated that the material being tested and the position of where the deflection readings are taken from affect the accuracy of the results. The material, beam configuration and load machine that yielded the most accurate results, was a simply-supported steel beam with deflection readings taken at mid-span. This can be seen by looking at Table #10 below, under the steel mid-span column.

To see the actual experimental and theoretical deflection values used to obtained the percent errors seen in tables 10 and 11 refer to tables 5 and 8 respectively, which can be found on pages 5 and 7.

Table#10 : Percent Error of Deflections (Part A)						
Load Applied (N)	Brass		Steel		Aluminum	
	Mid-Span	Quarter-Span	Mid-Span	Quarter-Span	Mid-Span	Quarter-Span
200	45.22%	42.92%	10.60%	4.09%	18.83%	19.17%
400	39.47%	42.64%	11.34%	11.65%	16.66%	63.63%
600	41.21%	42.92%	12.74%	13.97%	16.29%	16.58%
800	41.69%	43.35%	13.45%	15.14%	15.84%	16.22%
1000	41.94%	43.99%	13.98%	15.27%	15.63%	16.36%

Table#11: Percent Error of Deflection (Part B)		
Applied Load (N)	Brass	
	x=L	x=L/2
0.981	48.59%	63.13%
1.962	45.34%	57.92%
2.943	39.19%	51.56%
3.924	40.46%	52.71%
4.905	39.05%	50.63%

4. d

5. b

6. c

7. c

8. c

9. d

10. d

11. b

12. a

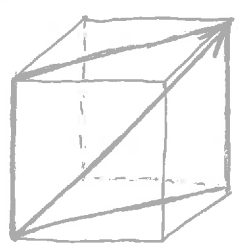
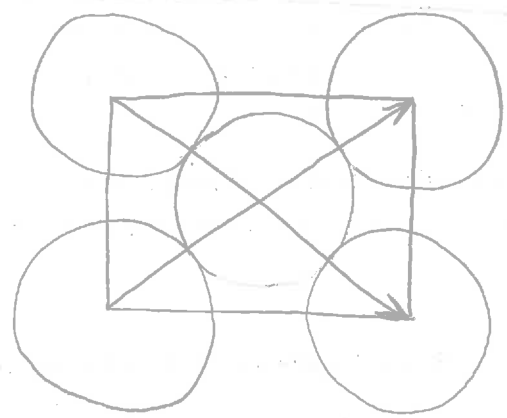
13. F

14. F

15. F

16. F

19.// edge: parallel
screw: perpendicular
mixed: neither

20.//  

21.// For small angle grain boundaries, the direction of slip will not need to change as much as large angle, when the dislocation crosses the boundary.