Lab #3 - Buckling of Columns

EGR 201L

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Introduction & Objective(s):

This lab attempts to measure the strength of Aluminum 6061 specimens with similar cross sectional areas, but varying lengths. These strengths are then compared with each other to examine the relationship between sample length and its effective strength. The data is then compared with expected values of each sample and reasons are speculated as to why differences in expected strengths may exist.

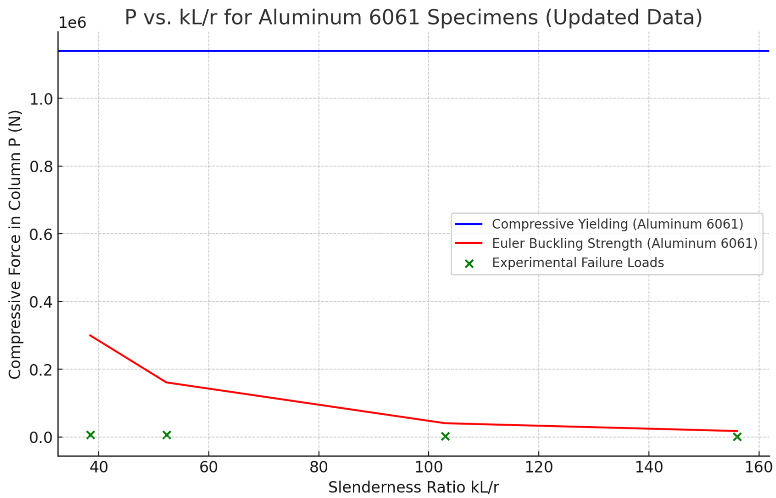
Methodology & Data:

Four aluminum 6061 samples of varying lengths were placed into a tension-compression testing machine. The failure load along with the dimensions of each sample were recorded in a data sheet (see - appendix A). Calculations regarding these data points are in the next section.

Results:

Question 2.

```
A = w% Specimen dimensions and properties
lengths = [3.485, 4.755, 9.929, 14.907]; % Lengths in cm
widths = [1.27, 1.269, 1.286, 1.281]; % Widths in cm
thicknesses = [0.314, 0.315, 0.334, 0.331]; % Thicknesses in cm
failure_loads = [249.994, 6916.657, 2301.660, 1116.663]; % Failure loads in N
% Material properties
E = 6.89e10; % Young's modulus in Pa (example value)
sigma_y = 2.41e+8; % Yield stress in Pa (example value)
k = 1; % Effective length factor (example value)
% Calculations
A = widths .* thicknesses * 1e-4; % Cross-sectional area in m^2
r = sqrt(A ./ pi); % Radius of gyration in m
kLr = k .* lengths .* 1e-2 ./ r; % Slenderness ratio
% Plotting
slenderness_range = linspace(min(kLr), max(kLr), 100);
P_y = sigma_y * A(1); % Compressive yielding (constant for all specimens)
P_cr = pi^2 * E .* A(1) ./ (kLr.^2); % Euler buckling strength
figure;
hold on;
plot(slenderness_range, P_y * ones(size(slenderness_range)), 'b-', 'LineWidth', 2); % Compressive
yielding line
plot(slenderness_range, P_cr, 'r-', 'LineWidth', 2); % Euler buckling line
scatter(kLr, failure_loads, 'k*'); % Experimental data points
xlabel('Slenderness Ratio kL/r');
ylabel('Compressive Force P (N)');
title('Compressive Force vs Slenderness Ratio');
legend('Compressive Yielding (P_y)', 'Euler Buckling Strength (P_cr)', 'Experimental Data', 'Location',
'best');
grid on;
hold off;
```



3. Percent differences in theoretical vs actual strengths:

Given, P_cr = pi^2 EA / (kL/r)^2 for k = 1 (fastened on both ends), we get theoretical strength for each specimen from smallest to largest, respectively: 18345.30N, 9940.99N, 2754.27N, and 2754.27N. Comparing these to our obtained values using the equation |Experimental Load - Theoretical strength| / Theoretical Strength * 100, we get the following errors:

For Specimen 1: 60.48%

For Specimen 2: 30.42%

For Specimen 3: 16.43%

For Specimen 4: 5.74%

4. The most obvious source of error stems from the way in which the specimens are secured to the machine. If the specimens are not perfectly perpendicular relative to the force being applied

by the machine, the results will become more inaccurate. This is exacerbated by how small the sample is, which is why the smaller samples had greater error.

5. Knife-edge notches help in applying the compressive load more precisely and uniformly along the specimen's longitudinal axis. This concentrated load application is crucial to ensure that the load acts purely axially, minimizing bending moments that could otherwise arise from off-center loading.

6. Original (scanned) data sheet from lab session - View Appendix A.

7. I enjoyed making predictions about the expected behavior of the samples prior to each test. It was interesting to see how the tests would confirm or deny my initial guesses and to see how far off I was in estimating the relative material strengths beforehand.

8. This lab may be improved by using more samples for data collection or comparing our results to anticipated results for aluminum 6061 to ensure that our data is accurate. Otherwise, the lab appeared to be well-organized and thought-provoking.

Discussion:

The deviances between tested and expected values got larger as the sample lengths got smaller, but were mostly consistent otherwise. This likely happened because the sample did not fit perfectly into the machine, any misalignments or situations where the specimen is not perfectly perpendicular would cause inaccurate results. These minor errors are exacerbated with smaller test sample lengths.

Feedback:

This lab was conducted with thoughtfulness and worked particularly well. If time permits, it may benefit from a comparison of expected data or extended tests with multiple samples to ensure correctness in data correction. Otherwise, no change is especially needed.

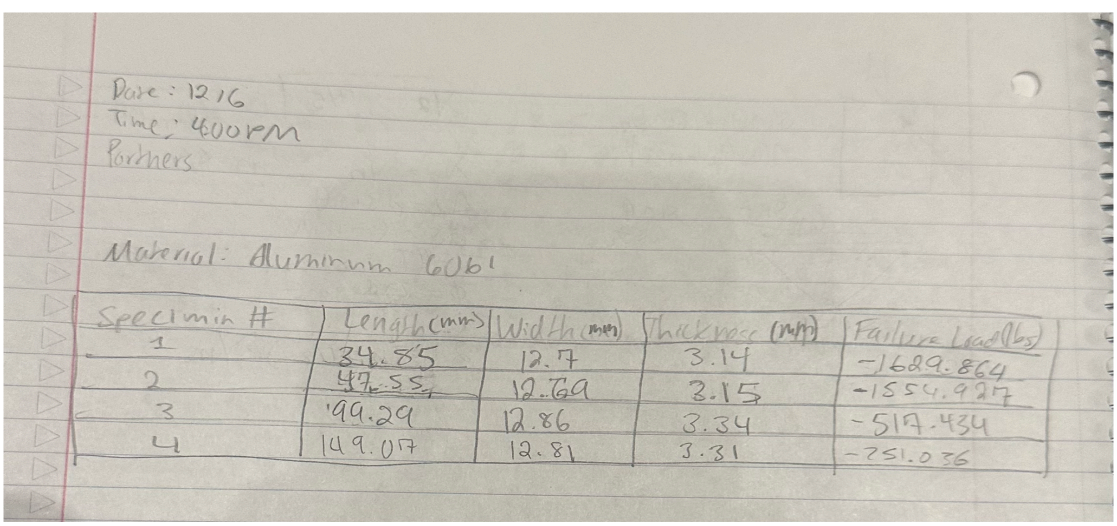
Conclusions:

This lab identified deviances between expected strengths in different sizes of the same type of aluminum samples. It confirmed the samples of smaller length (but same material and cross sectional areas) have a greater potential (and tested) strength.

References:

Duke EGR201L Lab 3 Manual

Appendix A - Data Sheet


Date: 12/6
Time: 4:00PM
Partners

Material: Aluminum 6061

Specimin #	Length (mm)	Width (mm)	Thickness (mm)	Failure Load (lbs)
1	34.85	12.7	3.14	-1629.864
2	47.55	12.69	3.15	-1554.927
3	99.29	12.86	3.34	-517.434
4	149.07	12.81	3.31	-251.036