Truss Project:

Buckling Lab Report

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Background

We desire to design, build, and test an acrylic truss structure to meet specified load requirements. The strength of the truss is expected to be limited by the buckling strength of the truss members. The buckling load is expected to depend on the length of the member. The purpose of this lab, therefore, is to measure the buckling strength of acrylic strips as a function of their length.

Methods & Data

We cut three strips of acrylic at 7 in, 11 in, and 15 inches using a yardstick and then scored the acrylic on top of a piece of cardboard. Snap the strip where the defect is to cut the strip. Turn on and zero the scale. Set the units on the scale to ounces. Place the strip horizontally on the scale and record the weight of each strip. Next, place the strip vertically in the center of the scale and apply pressure from the top with two fingers pressing down. The scale should increase as the strip starts to bend before decreasing and recording the maximum weight. Repeat for all three lengths for nine trials.

Analysis:

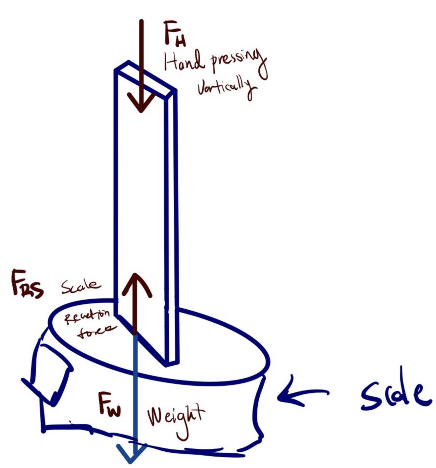


Figure 1: Free body diagram of pressing down the strip that lays vertically on the scale

Based on **Figure 1**, The equation of the Scale's reaction force is as follows:

$$\sum F_y = -F_H - F_W + F_{RS} = 0$$

$$F_{RS} = F_H + F_W$$

The strip is experiencing three forces. Gravity is the force exerted by hand on the strip and the reaction force of the scale. They are all in the vertical direction as the free-body diagram has shown. Among these three forces, F_H and F_W go downward which needs the reaction force of the scale to make it stable. Therefore the reaction force is going in the positive direction and equals to $F_H + F_W$.

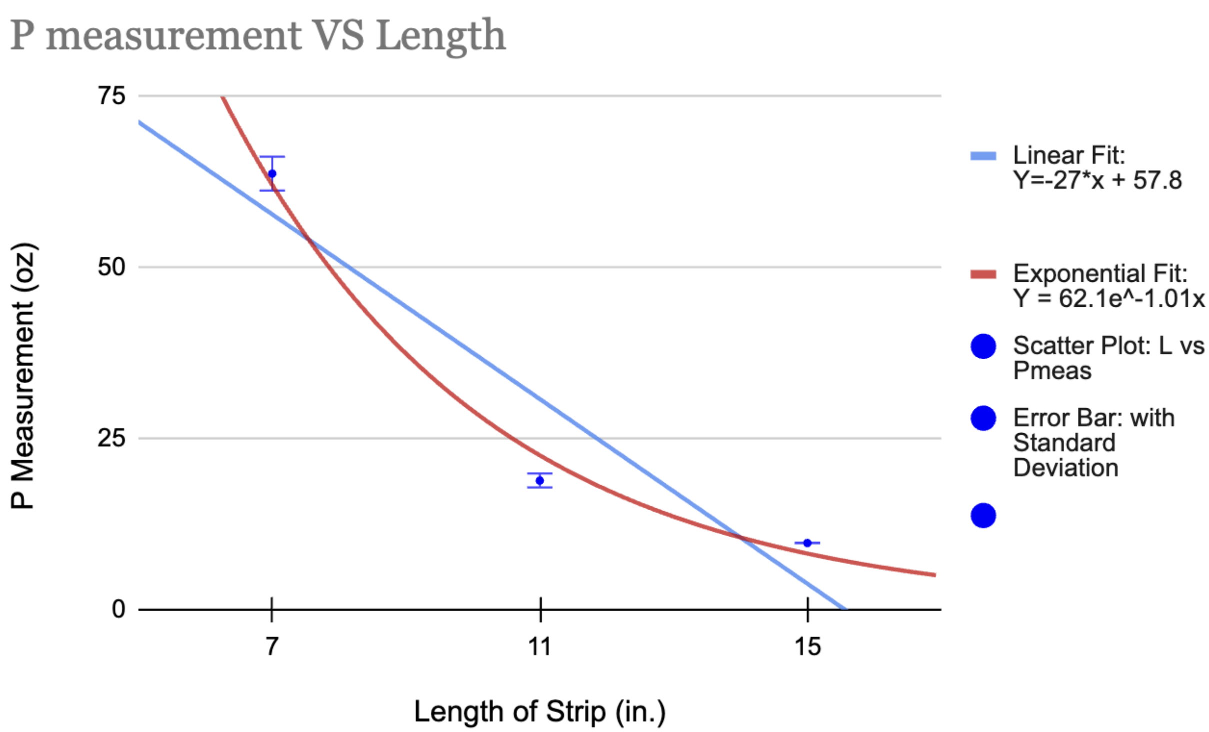
Results:

- Data Table:

	Length 7in.		Length:11in.		Length 15in.	
	Weight (oz)	P meas (oz)	Weight (oz)	P meas (oz)	Weight (oz)	P meas (oz)
trial1	0.55	60.3	0.85	18.21	1.15	10.2
trial2	0.55	65.25	0.85	17.8	1.15	10.05
trial3	0.55	64.95	0.85	19	1.15	10.3
trial4	0.55	65	0.85	19	1.15	9.75
trial5	0.55	64.06	0.85	18.4	1.15	9.4
trial6	0.55	67.25	0.85	18.35	1.15	9.65
trial7	0.55	64.2	0.85	19.6	1.15	9.4
trial8	0.55	59.4	0.85	21.2	1.15	9.55
trial9	0.55	63.3	0.85	18.4	1.15	9.4
Average		63.75		18.88		9.74
Range		7.85		3.4		0.9
Max:		67.25		21.2		10.3
Min:		59.4		17.8		9.4
Standard Deviation		2.47		1.02		0.356

- Plot Data:

Figure 2: Plot of strip lengths vs avg Pcrit, with linear fit, exponential fit and error bars



Discussion

We chose lengths 7 in, 11 in, and 15 in as they are the maximum, minimum, and in-between lengths. With each acrylic strip being used for all nine trials, the weight and length remain consistent in all trials. Each data point represents the P measurement value and accounts for error for each length. We observed that the P value decreases using the same strip for all nine trials, which we suspect that the bending of each trial wears down the strip and creates inaccuracies with the maximum buckling load possible with each length. Differences in the person performing the lab created inconsistencies in the P-measured data, since the P value depends on how well a person can balance the acrylic strip on the scale and how much pressure they can press down. Though the P critical values follow the general decreasing trend on the best linear fit, the data points do not lie on the line. Therefore we try the exponential fit, which gives a better fitting line than the linear as shown in Figure2. More specifically, for the error bar, we use Mean ± Standard Deviation. The error bar only overlaps with the trend line when the length is 7 inches. The trend line provides more uncertainty for the truss design as it is only based on three data points, whereas data made each point from 9 trials.

Conclusion

The 7 in has the highest buckling value and is the best length to support large weights. The buckling load was inaccurate, considering the same strip was used for nine trials, wearing it down and making it approach the minimum (59.4 oz) much quicker and the maximum (67.25 oz) less accurate. The ranges and general data show that the 7 in the strip has the highest buckling load with a P critical value of 63.7 oz and the longest length, 15 inches, with the lowest average buckling load of 9.74 oz.

Appendix

Case Study:

- There are situations where some group mates have less time than others. For example, if there is a test or loads of assignments awaiting. It’s acceptable to be a Couch Potato and Hitchhiker temporarily as long as it’s not consistent and is communicated with other group members.
- In the case of a couch potato or hitchhiker, one should not do all the work for them but can help, and remind them to take more action.

Group Contract:

- Individual work should be done 24 hours before the due date on Gradescope. If the temporary deadline is not met by the group mate, they should communicate with the group to extend the deadline, and ask for help or work on it collaboratively.
- We should communicate within the group chat about the parts that each of us is responsible for.
- If we find errors and unclear parts in the written parts, we should explain to each other the content or modify the reports.
- We should find a time for meetings when all group mates are available so all meetings should be attended by group mates, if an emergency comes up, then communicate to find another available time.
- The chair and recorder are on rotation every meeting
- If one group mate is sick, a meeting should be held on zoom. If there is a severe illness, other members will help