Final Design of Truss Design Project

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Introduction

We approached the selection for the design of our truss by focusing on the maximum load that the truss could support as well as looking at the cost/load ratio. To achieve the maximum load, we used our program to find the weakest member, the one that would buckle the first. Then, we changed the coordinates of this member to shorten its length. By repeating this process multiple times, we were able to achieve a relatively high max load. Then, we looked at the cost/load ratio and made minor adjustments to the lengths to attempt to minimize this. We did not completely disregard the uncertainty; we chose a design that when the failure weight was calculated with Pcrit as 2570/(L^2) -8.9oz (or weaker buckling strength value), it was still greater than the minimum 32 *oz* applied. Nonetheless, the design selection was based mainly on maximizing the failure load.

Procedure

We added code to easily determine the lengths of the members to make construction and analysis easier. This code created a length matrix that we then used to create our design as described below, optimizing the process of finding the best truss model. Code was added to avoid having to draw entirely new truss designs; instead we could shorten the predicted member to buckle without worrying if a member was out of the 6 to 15 *in* range. The added code checks if the member's length falls out of the range.

Analysis

Based on the failure weights of the trusses calculated during the preliminary design, a new truss design was chosen. The new design had a failure weight slightly over two pounds. As a result, we decreased the length of the member to buckle by varying the inputs until the original buckling member was only slightly over 6 *in*. For example, the original member to buckle was member 2, but as we shortened the member to barely over the minimum length, the new first member to buckle became member 3; member 3 was then shortened as the failure weight increased. This process was repeated while maintaining the conditions of a joint on the base 15 *in* away from the pin joint as well as being 29 *in* in length. The result was a truss, pictured in Image 1 of the result section, with a predicted maximum load of 59.2 ounces. As seen in Table 1 of the result section, members 9 and 11 are predicted to fail first.

The maximum load was calculated to be 59.2 ounces with an uncertainty of 13.7 ounces. The uncertainty was determined by altering the Pcrit function in our code using the class determined uncertainty for Pcrit of 8.9 ounces. Thus, the lowest calculated value was 45.5 ounces and the largest was 72.9 ounces which led to the calculated uncertainty of 13.7 ounces for the maximum load.

Results

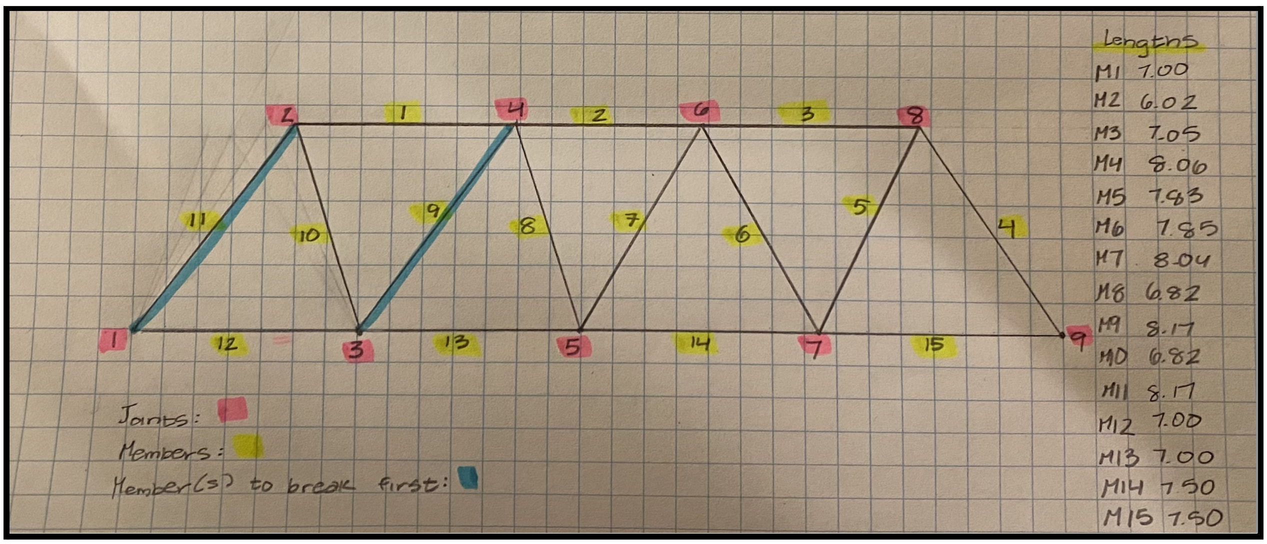
Table 1: Breakdown of Truss by Member, with failure members highlighted

Member Number	Length (in)	Tension (T) or Compression (C)	Internal Force at Nominal Maximum load (oz)	Buckling Strength and Uncertainty (oz)
1	7	C	2.062	52.45 ± 8.9
2	6.02	C	4.032	70.90± 8.9
3	7.05	C	1.914	51.71± 8.9
4	8.06	C	2.058	39.54± 8.9
5	7.83	T	1.998	
6	7.85	C	2.003	41.72± 8.9
7	8.04	T	2.436	
8	6.82	T	1.656	
9	8.17	C	2.406	38.50± 8.9
10	6.82	T	2.007	
11	8.17	C	2.406	38.50± 8.9
12	7	T	1.458	

13	7	T	3.520	
14	7.5	T	2.821	
15	7.5	T	1.021	

The maximum load is 59.2 oz. The cost of the truss is $200.82. The maximum load to cost ratio is 0.29 oz/$.

Image 1: Final Design Drawing



Discussion & Conclusion

Although writing the code was difficult, it was very useful as it made us think about the variations in trusses and allowed us to make many changes to the truss designs by just slightly changing the inputs of the locations of the joints. As a result, rather than having to repeatedly draw new truss designs in hopes of getting a larger maximum load, being able to see which member would fail and adjust the length of that member made it much easier to quickly test many variations. The final result we obtained for the maximum load makes physical sense. Our goal was to support at least 32 *oz*, and we accomplished this goal. It is within reason for our truss to hold that weight based on what we noticed in the buckling lab as well as the lengths of members. The greatest sources of error come from assembling the truss. Cutting the acrylic strips, assembling the pieces together, and finally tapping them might produce errors if not done correctly. For example, if some sort of internal tension between members because of taping Overall we learned that the best way to build our truss was to try and minimize the length of each member.

<u>Appendix</u>

Hartford Roof Collapse Discussion

Participants: Madelyn Keller (M), Gaby Kuntz (G), Diya Desai (D)

Date: 12/2/2021

Time: 6:00 pm

Place of the meeting: George Sherman Union

Chair of the meeting: Diya Desai

Recorder: Gaby Kuntz

- Designed a space frame roof that deviated from standard frame roof designs. (M)
- Too reliant on computer programs: computers are only as good as the programmer. (M)
- During the design, deflection was measured to be twice that predicted by computer analysis, no concern was expressed. The subcontractor had difficulty assembling due to this and was told by the general contractor to continue in order to avoid delays. (G)
- Important errors during testing were ignored: bowing in the members, insufficient bracing. (D)
- Many errors were made during the design: violating AISC code provisions, misplaces members and spacer pucks, and underestimation of the dead load. (M)
- Another error made was having 5 subcontractors and a construction manager, this left confusion on who was responsible for the project. The responsibility of a project should rest with one person. (G)
- Many errors during design and testing were ignored. The engineers were not being ethical. They knew there were errors in their design but chose to ignore them. (D)
- The responsible person for the collapse was the construction manager: ignored errors during the design and testing, refused to hire structural engineer, unethical- more worried about money and not delaying the project than human safety (G, D, M)