Final Design Report

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EK 301, Section A4

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Intro:

After our preliminary design process, we concluded that the most efficient and consistent approach was to use a relatively simple design, and optimize it as much as we could. This also allowed us to mainly focus on maximizing the maximum load the truss could support. This unfortunately meant we sacrificed a bit in the ways of uncertainty, but we were willing to accept this trade-off.

Procedure:

Our procedure was the same as the preliminary design report. Our MATLAB program makes a matrix A using C and the location matrixes. We then do T = (A^(-1)) * L, to get the load of each member under the live load.

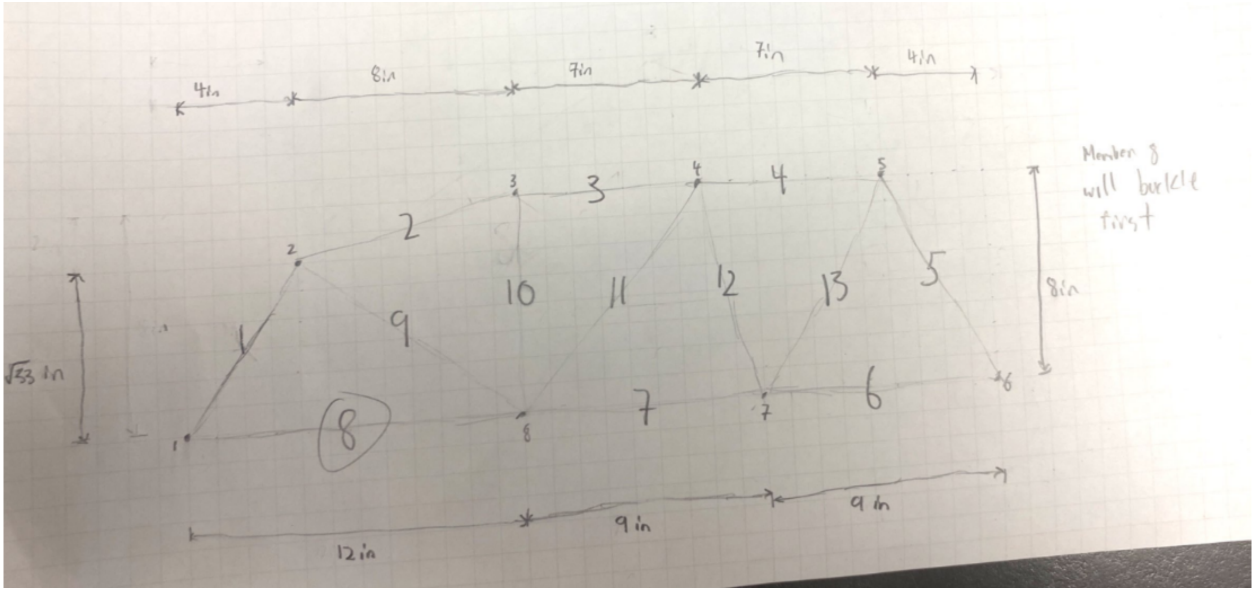
We then found the critical member and its Pcrit. We used the ratio of the Pcrit over the live load of the critical member, and multiplied the member forces, the support forces, and the live load to get the maximum values before buckling for all the values.

Analysis:

We did change our design somewhat significantly from the preliminary design report, although our truss analysis process still is the same. We learned that the 12in member at the bottom was often a critical member, and thus attempted to reduce the load on that. Furthermore, we noticed most designs with extreme differences in length were typically very ineffective. Keeping these things in mind, our actual design process is further elaborated in the discussion section.

For uncertainty, we used the class data to approximate the uncertainty for each member. Then to calculate the uncertainty for the maximum load, we used our MATLAB program and set our critical member to its maximum predicted buckling load to get the maximum predicted max load. We then did the same thing to calculate the minimum max load.

Results:



Member No.	Length (in)	Load (oz)	Buckling Strength (oz)	Load at max (oz)
1	7	19.89 (T)	N/A	35.79 (T)
2	8.31	25.43 (T)	N/A	45.77 (T)
3	7	24.48 (T)	N/A	44.06 (T)
4	7	12.24 (T)	N/A	22.03 (T)
5	8.94	12.16 (T)	N/A	21.89 (T)
6	9	5.44 (C)	36.36 + 6 - 6	9.79 (C)
7	9	14.96 (C)	36.36 + 6 - 6	26.92 (C)
8	12	11.36 (C)	20.45 + 4.5 - 4.5	20.45 (C)
9	9.85	16.15 (C)	30.36 + 5.5 - 5.5	29.06 (C)
10	8	6.90 (C)	46.02 + 6.8 - 6.8	12.42 (C)
11	10.63	14.46 (C)	26.06 + 5.1 - 5.1	26.02 (C)

12	8.25	11.22 (T)	N/A	20.18 (T)
13	9.43	12.83 (C)	33.09 + 5.7 - 5.7	23.09 (C)

Our critical member is 8, with a length of 12 inches. Its buckling strength is 20.45oz with an uncertainty of around plus or minus 4.5oz.

The maximum theoretical load is 48.95oz with a uncertainty of around plus or minus 10.7oz.

Our total cost was $194.42 and the max load to cost ratio is 0.252 oz/$.

Discussion/Conclusion:

Our design was a fairly simple one, as designing a complex one would be hard to iterate on and tedious to plug into MATLAB, However, our design was pretty well optimized. We shortened members 10 and 11 dramatically to reduce their Pcrits by decreasing the overall height of the truss, which ended up causing member 8 to be our critical member. Member 8 had to be 12 inches, so decreasing its length wasn't viable. Because member 1 is in tension, the x-direction force at joint 1 due to member 1 is to the left. Thus, decreasing the x-component of member 1 would cause the matching rightwards x-direction force due to the compression in member 8 to decrease. Thus, we were able to minimize the load of member 8 by making member 1 as vertical as we could without increasing the length of 9 too much. This also worked out well since it allowed us to decrease the height of our overall design by making member 2 more horizontal, which as mentioned above, was something we were after. Thus, we came to our final design.

At the end of the day, we learned a lot in the process of designing and building our truss. One of the most insightful parts was creating our computer analysis program from scratch, as it required understanding a lot of nuances about how trusses support loads. It was also useful seeing how minor changes affected our maximum supports, and how helpful the computer analysis can be. The process wasn't without flaw, and there were a few things we could have changed. We could have experimented with more radically different designs to see if a completely new design would be more effective, which might have allowed us to focus on other aspects besides maximum load.

Appendix:

<u>Meeting minutes of Center Collapse Discussion:</u>

11/30/22; 9:40pm

Mugar Basement

Howell, Karl, Andrew

Acting Chair: Howell

Minute Taker: Andrew

Planned Agenda:

- Use of computer analysis
- Failures of the hartford engineers
- Safety factors we would use in our own design

Andrew:

- They did not abide by the code of ethics because they did not communicate all information honestly and completely, they purposefully ignored multiple safety concerns, and didn't address problems during construction.
- They also dismissed concerns from the public.
- "Engineers shall hold paramount the safety, health, and welfare of the public."

Howell:

- Computer analysis can be efficient and useful, but it has flaws as it is very rigid and can only take in a limited number of variables. There is also a possibility of programmer error and it might be used as a crutch.
- They only used computer analysis instead of testing with any physical models.
- We would use physical prototyping to see if it behaves as the computer predicts (even at a small scale).

Karl:

- Computers allow engineers to iterate and test multiple designs quickly and efficiently.
- Endangered a lot of lives.

- We would make sure it’s constructed according to the design.

Conclusions:

The engineers behind the Hartford Stadium Collapse ultimately failed because of a lack of concern for public safety, and a lack of communication between engineers, construction workers, and the public.