EK301 Final Design

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Section A5
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Introduction

The purpose of the truss design project was for us to cooperate to create a truss design with the highest strength-to-cost ratio. Our team was tasked with researching and developing our own truss design with given financial and physical constraints during the process. From there, we used information from our preliminary designs and validation experiments to arrive at a design. For our design, we decided to focus more on the max load the truss could handle before critical failure. We also tried to keep the cost as low as possible as well as being under budget. Our approach to the final design was to build the strongest truss we could, so we tried our best to maximize the load applied to the truss.

Procedure

Fundamentally, we went back to the previous designs we created during our preliminary design report. We decided to change our designs to make them as strong as we could while keeping the cost as low as possible, essentially taking the best aspects of all previous designs and compiling them into our final design. We also used computational analysis to determine the best design we could make.

Analysis

For our analysis, we mainly relied on computer software since the building of the truss was to be done virtually. One aspect of the analysis we had to work with was how to accurately determine the maximum load of our design. We worked with the fact that the truss internal forces are proportional to the applied load. From there, we would be able to apply different loads to the truss for testing. We calculated the scaling ratio (SR) of the live and dead loads to the buckling load of the members. This was calculated by dividing the signed tension among the member by the expected critical buckling load for the member. We also had to account for the negative value of members in compression. This was done by adding a minus sign to the scaling ratio. Using this equation, we could estimate the maximum load the structure could hold. To account for our uncertainty, we used the critical load to find a range of uncertainty for the buckling load. We found three different cases of failure weight the truss. For the nominal case, our critical load was given to us by the computer software. The strong and weak cases of our truss were calculated by adding and subtracting the uncertainty respectively. The uncertainty value was provided by information from other groups in our section.

Results

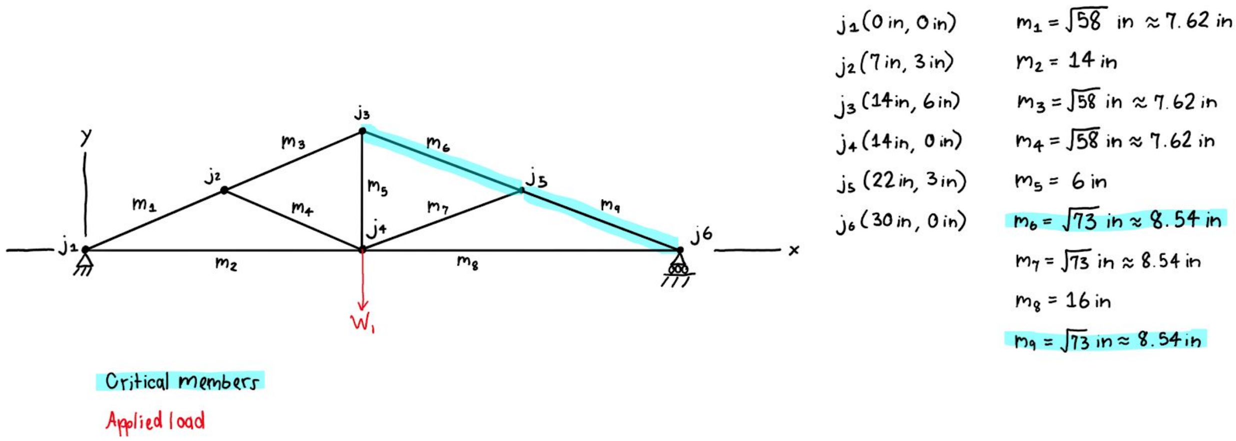

Figure 1*: A diagram of our final truss design. Joint coordinates and member lengths are listed on the right side, and critical members m_6 and m_9 are highlighted in green. The applied load is applied at joint j_4.*

Member #	Theoretical Member Length (in)	Tension/Compression	Weak Buckling Strength (oz)	Nominal Buckling Strength (oz)	Strong Buckling Strength (oz)	Magnitude of internal force (oz)
1	7.615773106	Compression	31.55871379	51.55871379	71.55871379	48.544
2	14	Tension	N/A	N/A	N/A	44.619
3	7.615773106	Compression	31.55871379	51.55871379	71.55871379	47.327
4	7.615773106	Compression	31.55871379	51.55871379	71.55871379	1.216
5	6	Tension	N/A	N/A	N/A	34.027
6	8.544003745	Compression	20.96445753	40.96445753	60.96445753	46.459
7	8.544003745	Compression	20.96445753	40.96445753	60.96445753	1.531
8	16	Tension	N/A	N/A	N/A	44.934
9	8.544003745	Compression	20.96445753	40.96445753	60.96445753	47.99

Figure 2*: A tabulation of the member number, theoretical member lengths, whether the members are in tension or compression, the buckling strength of each member with uncertainty, and the magnitudes of the internal forces.*

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>> truss_code

EK301, Section A5, Group 1: Zachary C, Stanley N, Michael O, 12/04/2020

Dead load: 7.087 oz

Live load: 30.822 oz

Member forces in ounces:
m1: 48.544 (C)
m2: 44.619 (T)
m3: 47.327 (C)
m4: 1.216 (C)
m5: 34.027 (T)
m6: 46.459 (C)
m7: 1.531 (C)
m8: 44.934 (T)
m9: 47.990 (C)

Reaction forces in ounces:
Sx1: 0.000
Sy1: 20.029
Sy2: 17.880

Cost of truss: $144.48
Theoretical max load/cost ratio in oz/$: 0.213

Critical member: 6
Critical member: 9
Theoretical critical load: 30.822 ounces
WARNING: member 6 has buckled.
WARNING: member 9 has buckled.
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Figure 3*: A screenshot of the output of the truss analysis code. Both the dead and live loads are listed at the top. The member forces, reaction forces, truss cost, critical members, and the theoretical critical load is presented above.*

Discussion

Our final design was similar to our preliminary design. Both designs are slightly askew so that the loading joint would be 14 in away from the pinned support, with the entire truss span being 30 in. The difference is that the final truss did away with two vertical members in an effort to minimize the overall height of the truss and increase the load-to-cost ratio. Model bridge-building resource website GarrettsBridges.com recommended that the height-to-span ratio of the truss be 1/6. Our first preliminary design had a height-to-span ratio of 1/3, and it had a theoretical critical load about 5 oz shy of the required critical load of 32 oz. Thus, we decreased the height of the truss to 6 in, bringing the height-to-span ratio to 1/5.

Appendix

- Zachary Capone, Stanley Nguyen, Michael Osuji met on both 12/3/20 & 12/4/20. With meetings on the prior from 5-7 pm and 9-10:30 pm. On the 4th, we met from 6:00 pm to 11:00 pm. All meetings were on a mixture of Discord and Zoom. Zoom was only used for the whiteboard feature. The first 45 minutes of the first meeting were dedicated to discussing the Hartford Roof Collapse, while all other time was devoted to working on the other components of the project. We spend exactly 7 minutes on each bullet point.

Agenda:	Beginning	Process	Outcome
5:00pm-5:45pm 12/3/20	Discuss the Hartford Roof Collapse and lay out bullet points of the main ideas.	Address each bullet point presented by the other members and base the discussion around that.	Record each of the points and document our conclusions about them.
5:45pm-7:00pm / 9:00pm - 10:30 pm	Split up while in a meeting and distribute tasks.	Michael works on the code and bridge design, Stanley works on the upper portion of the report, and Zachary works on the lower portion of the report.	Over half the report is done and ready for revision on the fourth.
6:00pm - 11:00pm	Revise and sharpen work from the previous day while opening room to enter the rest of the data from the calculations and their conclusions.	Michael will finalize data collections from our Truss simulation and fill in the results, Stanley will help Michael and copy the data onto our report, Zachary, the timekeeper, will copy the agenda onto the report and revise pre-existing components of the	All parties will revise over the report and once all satisfied will submit. We will then meet tomorrow at 11 for the digital testing of our design.

		report.	

- **Points Of Interest:**
  - Ignoring the results of the simulations as well as the failure of the components during the construction process. *-Michael Osuji*
  - Although conflicts to the construction were brought up to many of the engineer's attention, they were all neglected. The engineer had an ego and was sure his design and computer analysis were correct. *-Stanley Nguyen*
  - Aggression shown towards the construction company as well as threatening them with blame for the failure of the roof should they refuse to install it. -Stanley Nguyen
  - Potential to kill large quantities of people and luck affiliated with a victimless collapse. *-Michael Osuji*
  - Complete and total disregard for the Code of Ethics of Engineers or even anything remotely similar to what would be ethical regard for the quality of the final structure, the customer's wishes, the contracted construction company, safety, and even human life itself. *-Zachary Capone*

- **Conclusions of Previous Points of Interest:** *Presented in the same order as above.*
  - Engineers ignored the poor and failing results of simulations and physical components, most likely out of callousness and laziness.
  - Continued rejection of both criticisms and failures during the construction process demonstrate the engineers were unconcerned about the consumer, quality of their work, or safety of the building's inhabitants.
  - Clear and open threats towards the construction company in order to have them stop trying to contact and voice concerns to the engineers demonstrates a clear awareness amongst the engineers in regards to the structural concerns of the roof, and a priority on finishing the contract and a payout alone.
  - The fact that these engineers knew a failure would likely kill hundreds of people and went through the process callous towards serious structural failures shows not only were these very poor quality engineers, but also poor quality people, to put it mildly.
  - These people should not only never be engineers, but also never in a position where their decisions have a major impact on the safety or wellbeing of other people.

- In our meetings, we covered all points mentioned in our report and believe our discussion regarding the material was satisfactory. We do not plan on meeting for another time on the due date with the intention of talking about the Hartford Roof Collapse as we believe it is unnecessary.