The Buckling Bucklers

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Project: Part 4 "Model Verification and Preliminary Design"

EK301: Section A3 (Fall 2020)

Professor Holt

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Introduction

Describe your motivation and approach for your final design; did you focus on cost? on max load? on load-to-cost ratio? on a combination? Did you strive to minimize uncertainty? disregard uncertainty to maximize predicted strength?

To approach the design of our final truss, we focused on optimizing the load to cost ratio by drawing our different designs and testing them using our MATLAB program. The math model helped us efficiently test multiple truss designs, without doing all the calculations by hand or physically building and testing the models. For each layout of joints and bars, we tried multiple different truss heights, and ultimately came up with the truss design with the greatest load-to-cost ratio. We used the theoretical buckling strength calculated by the program, disregarding the lower and upper limits for uncertainty.

Procedure

Describe any changes you made in the design procedure since the preliminary design report. (If you have not made any changes, state that.)

The programming aspects of the procedure stayed the same. Our original code gave us the load to cost ratio and that was the prioritized outputted value from the code. We tested a bunch of different trusses and compared each truss' Wfail, cost, and the load to cost ratio. The truss we chose had the biggest load to cost ratio of .2476. The procedure for the physical construction of the truss stayed the same. We would base the dimensions of the truss on graph paper, overlapping the truss on a grid. This made it easier to find the coordinates for the joints, with the pin joint being at the origin, (0,0).

Analysis

Note any changes from your analysis used in the preliminary designs. What specific formulas or methods did you use to account for uncertainty, if at all?

From the preliminary designs there are no changes in the analysis of the trusses, or changes in any formulas used. We did not complete any of the calculations by hand, like we had done in the preliminary design, because we had already verified our model. In order to account for the uncertainty, we used the same method for determining the weak and live load as delineated in the model validation portion of the project. Our realistic model assumed a theoretical maximum load closer to the lower range of the uncertainty, in order to avoid a situation similar to what we learned about in the Hartford Roof Collapse discussion. Our nominal model did not account for uncertainty, and simply used the nominal W_{fail} value calculated by the program.

Results

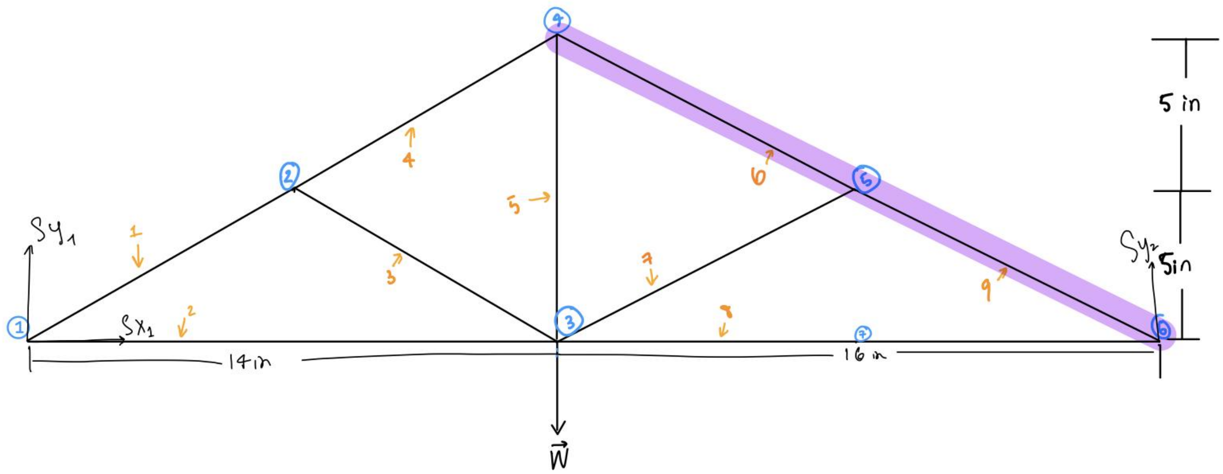

Figure 1: This figure shows the free body diagram of our final truss design including member numbers that correspond to those in the program output shown in Table 1. The joint numbers are in blue. The member numbers are in orange. The highlighted member is the member that fails first. The reaction forces are labelled with vectors Sy1, Sy2, and Sx1.

Member #	Joint-to-joint theoretical member length (in)	Tension (T) or Compression (C) or Zero Member Force (0)	Buckling Strength + Uncertainty (oz)	Internal Force at Max Truss Load (oz)
1	8.60	C	40.4 ± 20	40.4
2	14	T	NaN	32.8
3	8.60	0	40.4 ± 20	0.94
4	8.60	C	40.4 ± 20	39.4
5	10.0	T	NaN	41.8
6	9.43	C	33.6 ± 20	37.8
7	9.43	0	33.6	1.13
8	16.0	T	NaN	33.0
9	9.43	C	33.6 ± 20	39.0

Table 1: This table displays the Joint-to-joint theoretical member length, whether the member is in compression, tension, or neither, the buckling strength and uncertainty, and the force at the maximum truss load including dead load for our final truss design pictured in Figure 1.

	Maximum Load (oz)	Truss Cost ($)	Load-to-Cost Ratio (oz/$)
Nominal Truss	38.15	154.11	0.2476
Realistic Truss	10	154.11	0.0649

Table 2: The table above shows the Maximum Load, Truss Cost, and Load-to-Cost Ratio for the Nominal Truss and Realistic Truss models.

Discussion

<u>Discuss the rationale for your design, including how you optimized it. Describe how your design evolved and what design decisions you made along the way.</u>

In order to determine our final design, we worked off of one of the original trusses we had designed, shown in Figure 2. We noticed that member 3 and 11 were zero force members, and thus not contributing effectively to the load-to-cost ratio. Therefore, we removed those two bars, and the load-to-cost ratio significantly improved, from 0.18 to 0.2476. In addition to altering our original design, we drew a few new ones, as shown in Figure 3, but upon testing, our original design with some alteration was the most successful.

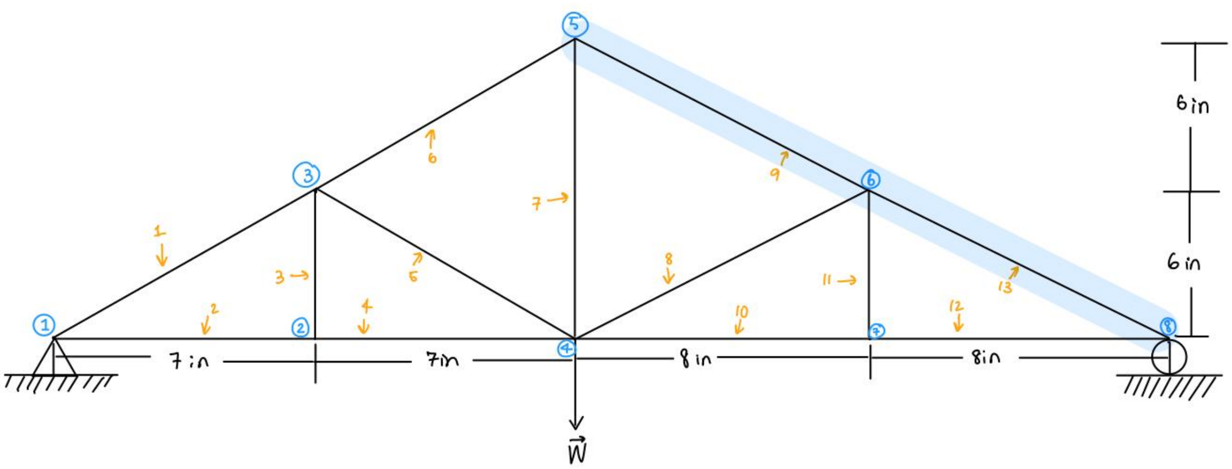

Figure 2: This figure shows the free body diagram of our first truss design including member numbers that correspond to those in the program output in Figure 4 and Table 2. The joint numbers are in blue. The member numbers are in orange. The highlighted member is the member that fails first. The load-to-cost ratio for this truss is 0.18.

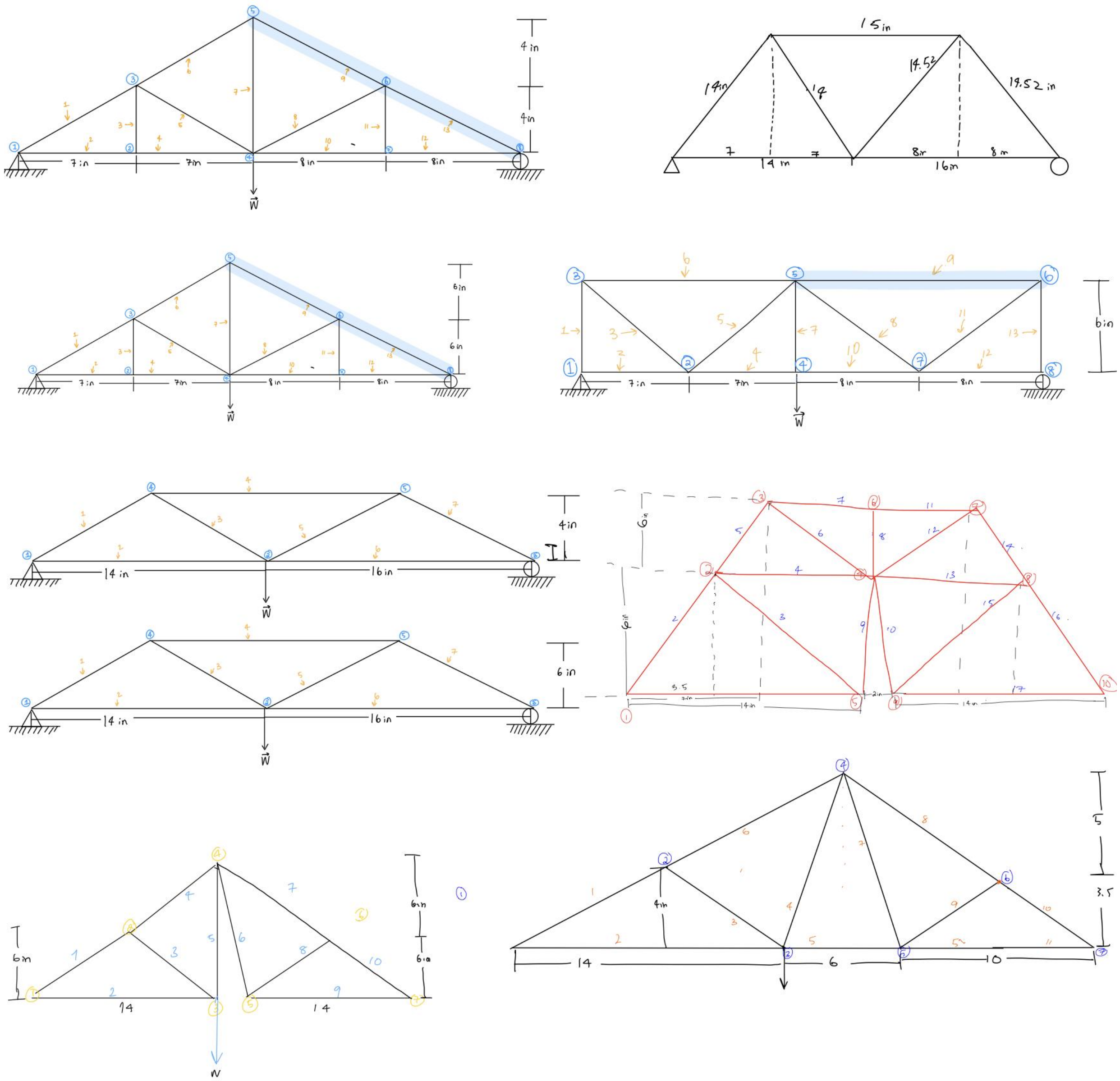

Figure 3: This figure above shows the free body diagram of all the designs our group came up with and tested using our computer program. Ultimately the design shows in Figure 2 had the greatest load-to-cost ratio, so we picked it to be our final truss design.

Appendix

Category	Planned Agenda: Important Points/Action Items/ Conclusions	Location	Date/Time	Participants/Roles
Buckling Lab	Gather data Action item: Report data tables to google drive - Dea Conclusion: Created a shared google doc.	GSU	Thursday, Oct 5, 6-9pm	Dea Turashvili- *Chair* Mark Vinciguerra- *Minute Taker* Felix Flores
	Finish Report Action item: Follow the instruction manual outline - Felix Conclusion: Finished the report.	GSU	Sunday, Oct 4, 6:30-9:30	Mark Vinciguerra- *Chair* Dea Turashvili- *Minute Taker* Felix Flores
Model Verification and Preliminary Design	Read and Understand Manual Action item: Spend a whole hour solely reading and understanding the manual - Mark Conclusion: Summed the manual up in bullet points on paper.	Zoom	Friday, Oct 23, 4pm-6pm	Felix Flores- *Chair* Mark Vinciguerra- *Minute Taker* Dea Turashvili
	Begin Writing Code Answer Model Verification Problem by Hand Action item: Record the amount of minutes this took! - Dea Conclusion: Basically finished code, had to go to office hours for minor bugs.	Zoom	Saturday, Oct 24, 12pm-6pm	Mark Vinciguerra- *Chair* Felix Flores- *Minute Taker* Dea Turashvili
	Finish Writing Code Come up with 2 Truss Designs Action item: Redo truss design because it doesn't follow parameters - Felix Conclusion: Eventually came up with two solid truss designs that followed the parameters.	Zoom	Sunday, Oct 25, 1pm-8pm	Felix Flores - *Chair* Dea Turashvili- *Minute Taker* Mark Vinciguerra

	Create Input Files for 2 Truss Designs Run Both Truss Designs Action item: Identify the problem with one of the input files - Mark Conclusion: The C matrix had more than one 1 in a column.	Zoom	Tuesday, Oct 27, 5:30pm - 9pm	Dea Turashvili- *Chair* Felix Flores - *Minute Taker* Mark Vinciguerra
	Write up Report Action item: Go to office hours to discuss uncertainties - Dea Conclusion: LA's came out with Pcrit data from Buckling Labs for the class. Referred to that for uncertainties.	Zoom	Wednesday, Oct 28, 3pm-8pm	Dea Turashvili- *Chair* Mark Vinciguerra- *Minute Taker* Felix Flores
Model Validation	Design Test Truss Run Code for Test Truss Action Item: Gather all materials for construction -Dea Conclusion: All pooled our materials together	Stu-Vi Study Space	Wednesday, Nov 18, 6pm-9pm	Mark Vinciguerra- *Chair* Dea Turashvili- *Minute Taker* Felix Flores
	Build Test Trusses Action Item: Put the truss design pictures into Report - Dea Test Test Trusses Action Item: Put truss test and mechanism pictures into report - Mark Conclusion: Trusses have been successfully tested.	Stu-Vi Study Space	Saturday, Nov 21th, 2pm- 6pm	Felix Flores- *Chair* Mark Vinciguerra- *Minute Taker* Dea Turashvili
	Write Up Report Action Item: Everyone comes up with one possible truss design to test during the next meeting. - Felix Conclusion: Model Validation Report is written.	Zoom	Sunday, Nov 22th, 1pm-8pm	Mark Vinciguerra- *Chair* Felix Flores- *Minute Taker* Dea Turashvili
Final Design Report	Determine Final Truss Design Action Items: Brainstorm some new possible designs. And Read the Harford Roof Collapse Article. -- All members	GSU	Tuesday, Dec 1, 6pm-10pm	Felix Flores - *Chair* Dea Turashvili- *Minute Taker* Mark Vinciguerra

	Conclusion: Final Design chosen, but still open to new ideas.			
	Discuss Hartford Roof Collapse Conclusion: We discussed that the use of computer programs in analysis and design is not foolproof, and thus in real life application the lower bar for uncertainty values should be used when considering how much weight a truss(or other object) can hold. We would claim a max load of 6.5oz, as it was our lower bound for the uncertainty. Write Up Report Action Items: 1. Mark works on Intro and Results. 2. Dea Works on Procedure and Discussion. 3. Felix Works on Appendix and formatting Conclusion: Report was successfully written.	GSU	Thursday, Dec 3, 3:15pm - 9pm	Dea Turashvili- *Chair* Felix Flores - *Minute Taker* Mark Vinciguerra

Team Member's Name	Team Member's Signature
Dea Turashvili	Dea Turashvili
Mark Vinciguerra	Mark Vinciguerra
Felix Flores	Felix Flores