Preliminary Design Report

Howell Xia, Andrew Chen, Karl Carisme

EK 301, Section A4

Fall 2022

Intro:

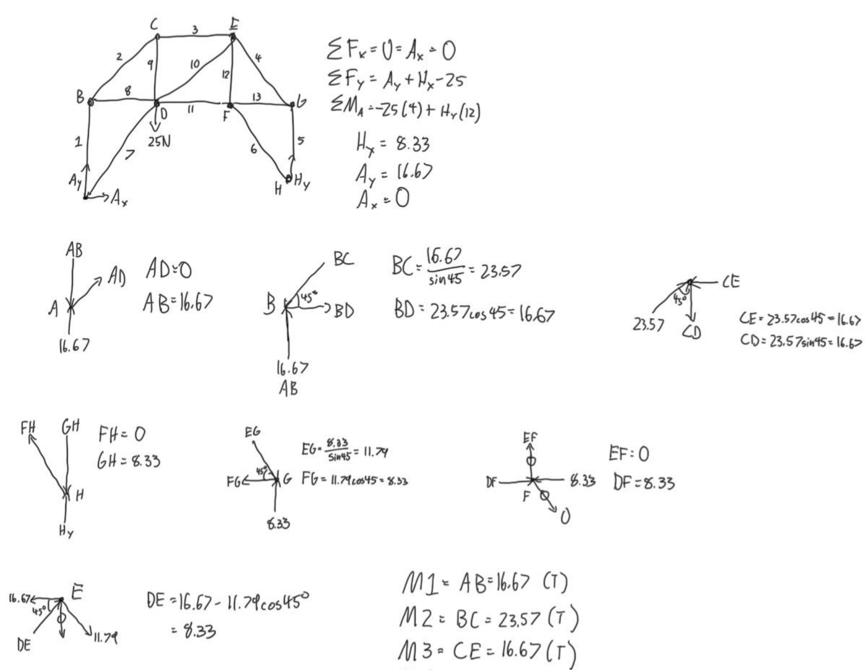
We want to use a computer program to analyze trusses as it is far more efficient than doing it by hand and allows us to test several different designs quickly. We will use the program to evaluate truss designs through trial and error, an option not feasible by hand.

Method/Analysis:

Our calculations for the example truss problem. Our computational approach was the same approach given by the packet, where we make 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.

Solution to example problem:



M1 = AB = 16.67 (T)
M2 = BC = 23.57 (T)
M3 = CE = 16.67 (T)
M4 = EG = 11.79 (T)
M5 = GH = 8.33 (T)
M6 = FH = 0
M7 = AD = 0
M8 = BD = 16.67 (C)
M9 = CD = 16.67 (C)
M10 = DE = 8.33 (C)
M11 = DF = 8.33 (C)
M12 = EF = 0
M13 = FG = 8.33 (C)

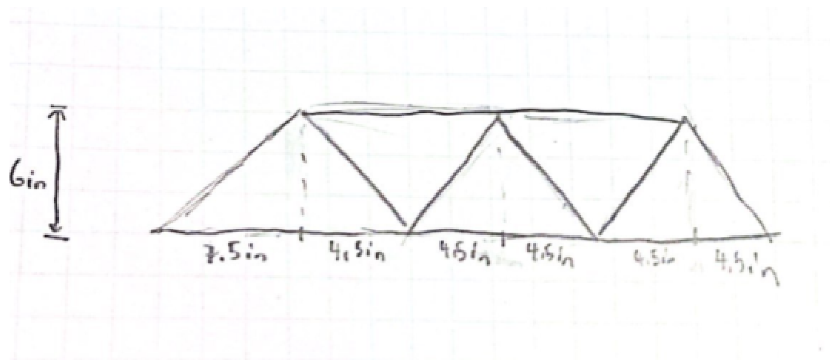
```
EK301, Trussty Partners, Section A4
All units in oz

Load: 25.00 oz

Member Forces:
M1: 16.667 (T)
M2: 23.570 (T)
M3: 16.667 (T)
M4: 11.785 (T)
M5: 8.333 (T)
M6: 0.000 (C)
M7: 0.000 (C)
M8: 16.667 (C)
M9: 16.667 (C)
M10: 11.785 (C)
M11: 8.333 (C)
M12: 0.000 (C)
M13: 8.333 (C)

Reaction Forces:
Sx1: 0.000
Sy1: 16.667
Sy2: 8.333

Cost: 140.28
Theorectical max load/cost ratio in oz/$: 0.696
```

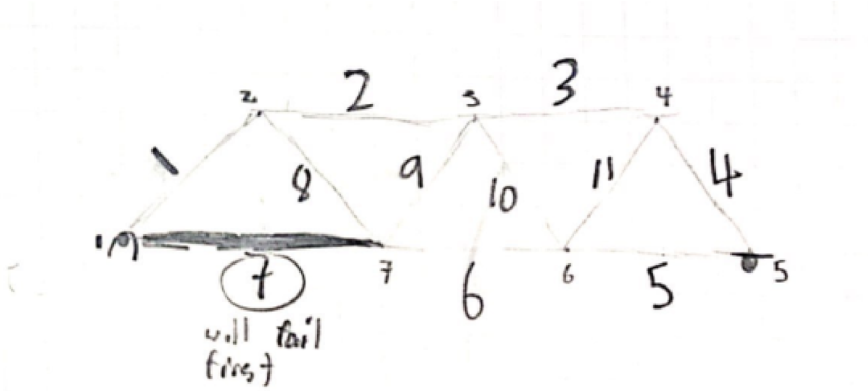
The member that will buckle first is member 2, as it experiences the largest force while having the smallest Pcrit. Member 2 has a length of 5.66 inches, with a buckling strength of 92oz, giving us an uncertainty of around plus/minus 5oz according to the class data.

The maximum load that the example truss can support is 97.6oz, with an uncertainty of around plus or minus 20oz.

Results:

Design 1:





Member No.	Length (in)	Load (oz)	Buckling Strength (oz)	Load at max (oz)
1	9.6	26.13 (T)	N/A	26.19
2	9	32.64 (T)	N/A	32.72
3	9	16.32 (T)	N/A	16.36
4	7.5	13.60 (T)	N/A	13.63
5	9	8.16 (C)	36.35 + 4 - 6	8.18
6	9	24.48 (C)	36.35 + 4 - 6	24.54

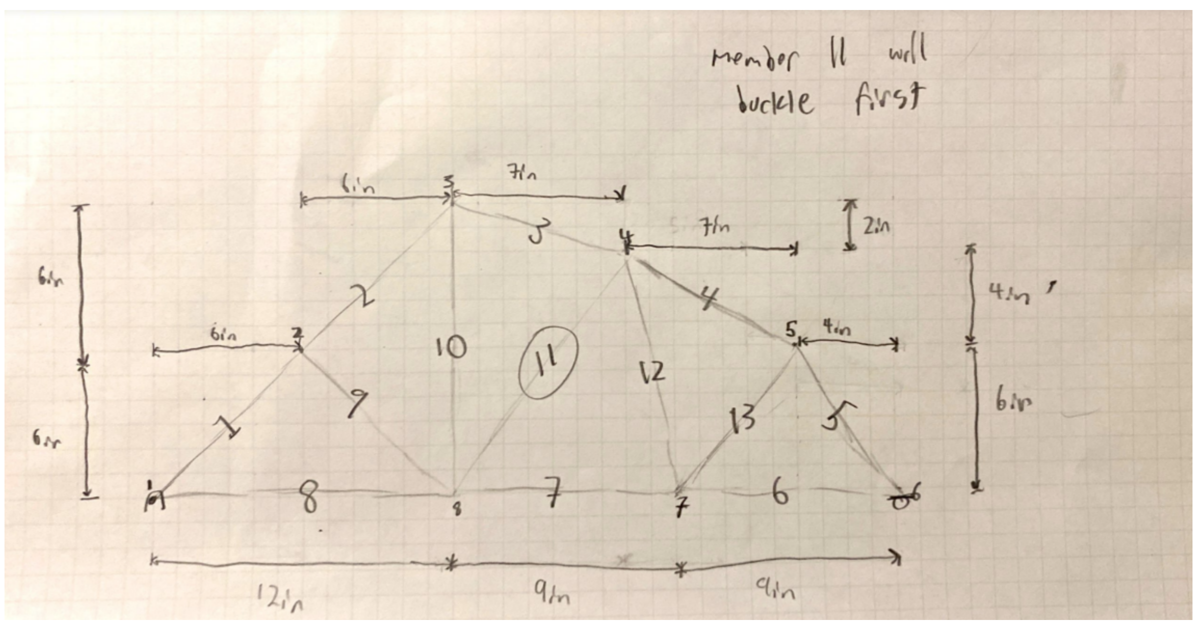
7	12	20.40 (C)	20.45 + 6 - 5	20.45
8	7.5	20.40 (C)	52.36 + 5 - 5	20.45
9	7.5	13.60 (C)	52.36 + 5 - 5	13.63
10	7.5	13.60 (T)	N/A	13.63
11	7.5	13.60 (C)	52.36 + 5 - 5	13.63

Our critical member is 7, with a length of 12 inches. Its buckling strength is 20.45oz with an uncertainty of plus or minus 5oz.

The maximum theoretical load is 27.27oz with a uncertainty of around plus or minus 5oz.

Our total cost was $165 and the max load to cost ratio is 0.165 oz/$.

Design 2:



Member No.	Length (in)	Load (oz)	Buckling Strength (oz)	Load at max (oz)
1	8.49	23.08 (T)	N/A	60.11 (T)
2	8.49	23.08 (T)	N/A	60.11 (T)
3	7.28	16.97 (T)	N/A	44.20 (T)
4	8.06	12.73 (T)	N/A	33.16 (T)
5	7.21	13.08 (T)	N/A	34.06 (T)
6	9	7.25 (C)	36.36 + 4 - 6	18.89 (C)
7	9	11.97 (C)	36.36 + 4 - 6	31.17 (C)
8	12	16.32 (C)	20.45 + 6 - 5	42.50 (C)
9	8.49	0 (C)	40.90 + 4 - 6	0 (C)
10	12	20.98 (C)	20.45 + 6 - 5	54.65 (C)
11	12.2	7.59 (C)	19.77 + 6 - 5	19.77 (C)
12	10.2	4.65 (T)	N/A	12.11 (T)
13	7.81	5.94 (C)	48.27 + 5 - 5	15.47 (C)

Our critical member is 11, with a length of 12.2 inches. Its buckling strength is 19.77 oz with an uncertainty of around plus 6 oz and minus 5 oz.

The maximum theoretical load is 70.84oz with a uncertainty of around plus or minus 5oz.

Our total cost was $200.22 and the max load to cost ratio is 0.365 oz/$.

Discussion/Conclusions:

Overall we noticed that using shorter lengths was more successful, however, we are limited by a minimum length of 7 inches. Additionally, the only multiple of 12 we have access to being 12 made efficient design difficult.

For our first design, the max load to cost ratio was decent, but this was due to the low cost as the max load was really quite low. Our max-load uncertainty would have put us at risk of buckling under the given load, and thus, we believe is our inferior design. Our second design, while costing a considerable amount more, had a much better design and supported a far larger max load. The second design was not at risk of buckling at all. The difference between the designs was the number of joints and members. In design 2, there were additional members that while they did not contribute much (like members 12, 13 and 9), they broke up the design and other members into smaller members which increased the Pcrit's of those members considerably. Our first design was far more simple and had longer members, thus causing it to buckle under lighter loads. Ultimately, we believe our second design to be superior.

We hope to further improve our designs by adding more joints and members to distribute the load more and break up the long members, as we still have a decent amount of money to work with in both designs.