TERM PROJECT FOR STRUCTURAL ANALYSIS 2 – CIV519

Part a, Introduction:

This entry is about an individually done term project of a 4th year technical elective course called structural analysis 2. The project required us to make a detailed analysis of a research paper related with course material, mainly the steel trusses. The main goal of this project was to practice the course material and learn about the trusses that are used in real life. Another important goal of it was to improve our ability on analysing a published report. The project also indirectly aimed at the usage of computer software for solving complex structural loading systems that will take long time to solve by hand. The paper this project was about is linked at the part b of this entry.

The paper was talking about an analysis method called the two-stage method. The method was proposed by Janusz Rebielak, a Polish professor at the department of architecture in Cracow University of Technology. The method was inspired from the buckling analogy of steel under compression. His method was based on the principle of superposition and it was for approximately solving appropriate statically indeterminate plane trusses.

I broke the analysis in four parts mainly focusing on historic and current bridges since steel trusses like mentioned in the report are encountered mostly on bridge designs. In the first part, I repeated the examples shown in the paper using mostly RISA-3D and compared my results with the results of the paper. In the second part, I examined the applicability of the proposed two-stage method to 4 widely used truss types. In the third part, I commented and discussed on possible limitations of the proposed method and in the final part I gave my opinion about the method proposed as well as pointed out some possible mistakes.

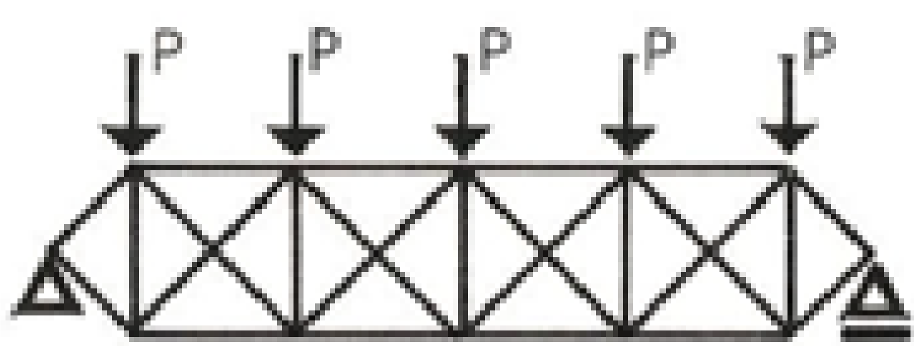
I found this project to be particularly helpful in improving my discussion, interpretation of data and commenting skills. I also practiced my ability to use a commercial design and analysis software and learned new functions of it. I believed in the usefulness of this project and spent considerable time and effort on this project since as a future structural engineer, I know that reading and analysing reports will be a substantial part of my work.

Part b, the paper:

The paper is called "New Simple Method of Calculation of Statically Indeterminate Trusses" and can be found online at: http://www.sci-en-tech.com/apcom2013/APCOM2013-Proceedings/PDF_FullPaper/1594_J_Rebielak.pdf. The original version can also be found in UofT's engineering library. It was also published in 2014 in the Journal of Mathematics and System Science 4 (p367-371).

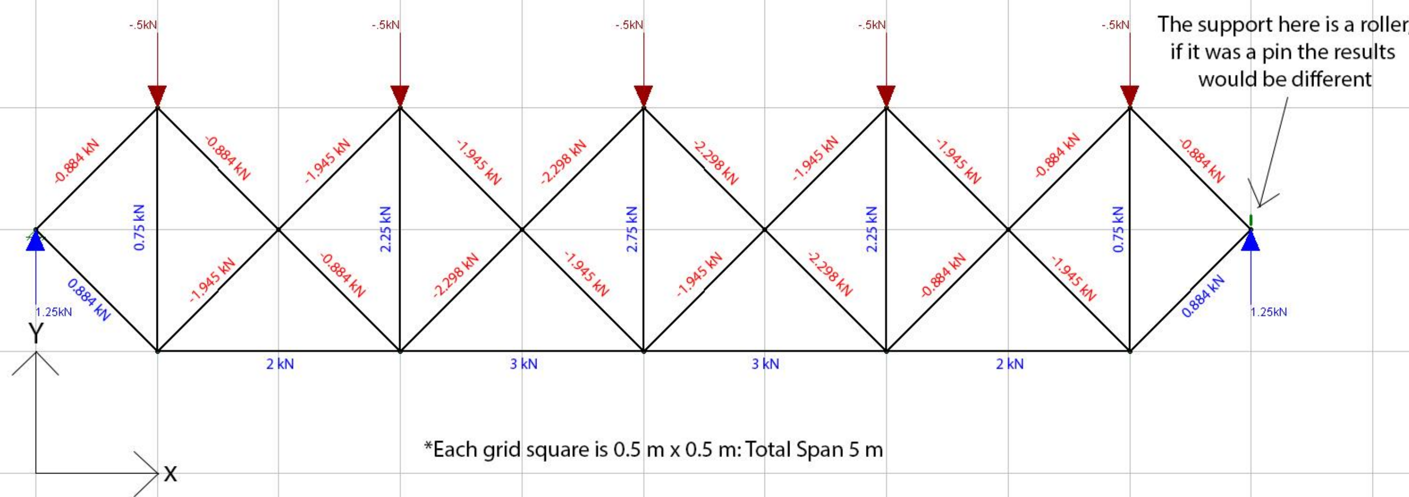
Part c, the repeated examples from the paper, results and my commentary:

Below are my analysis results for the first example studied at the paper:



FORCE VALUES IN THE FIRST STAGE (COMPUTER RESULTS: FIRST ORDER LINEAR ELASTIC)

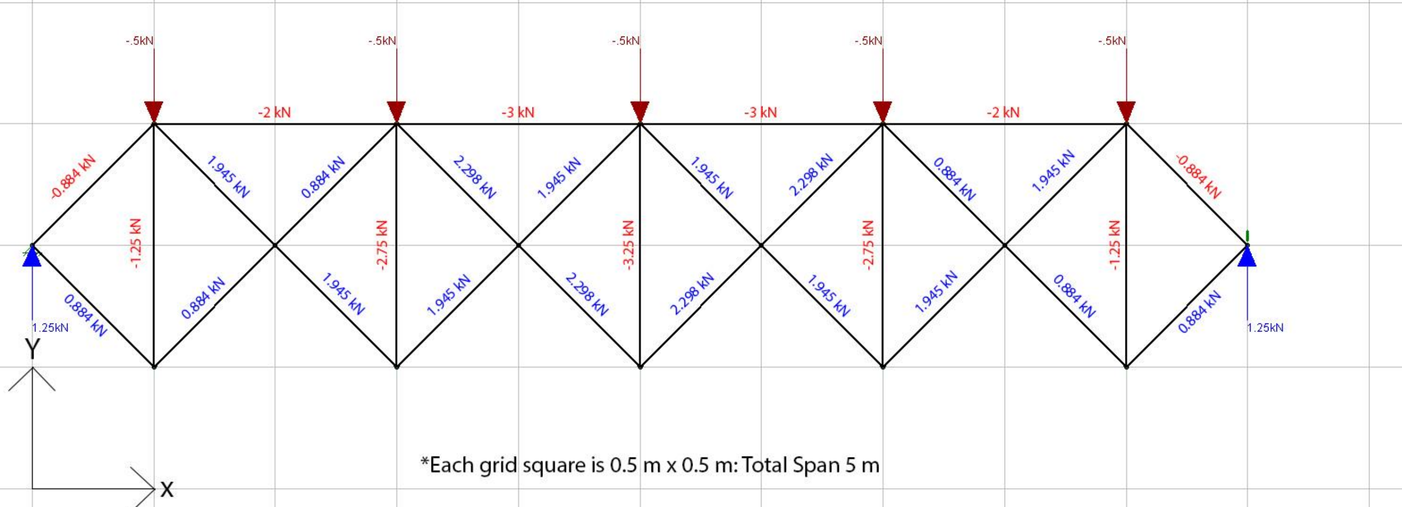
Tension (+), Compression (-)



*Each grid square is 0.5 m x 0.5 m: Total Span 5 m

FORCE VALUES IN THE SECOND STAGE (COMPUTER RESULTS: FIRST ORDER LINEAR ELASTIC)

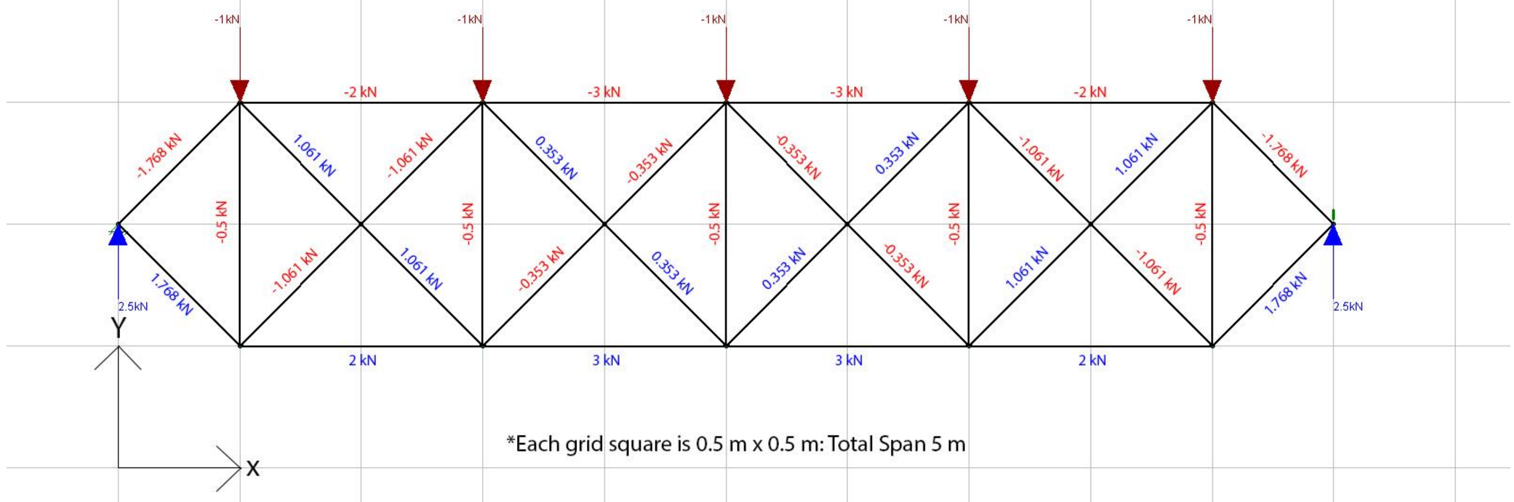
Tension (+), Compression (-)



*Each grid square is 0.5 m x 0.5 m: Total Span 5 m

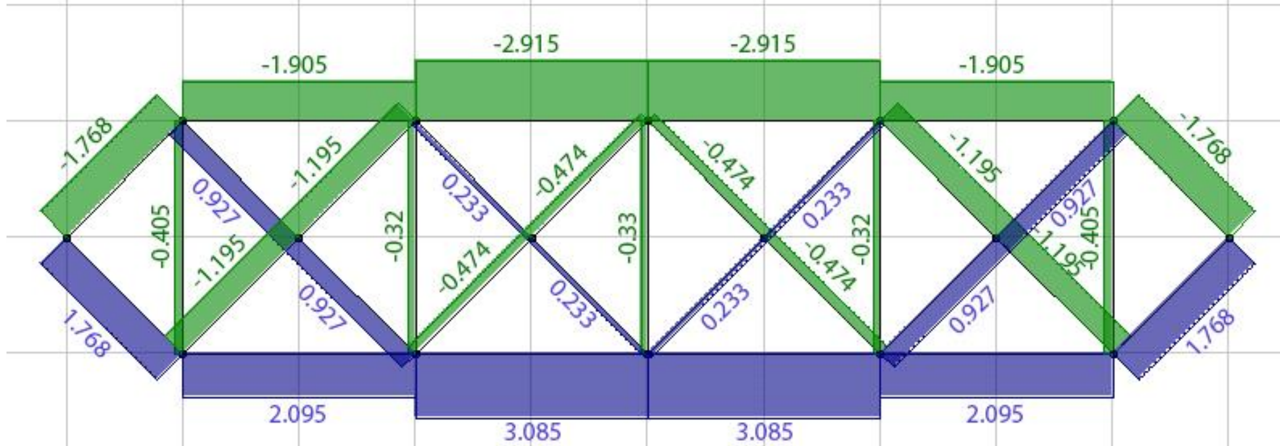
FORCE VALUES AFTER APPLYING SUPERPOSITION OF THE FORCES OPTAINED IN TWO STAGES

Tension (+), Compression (-)



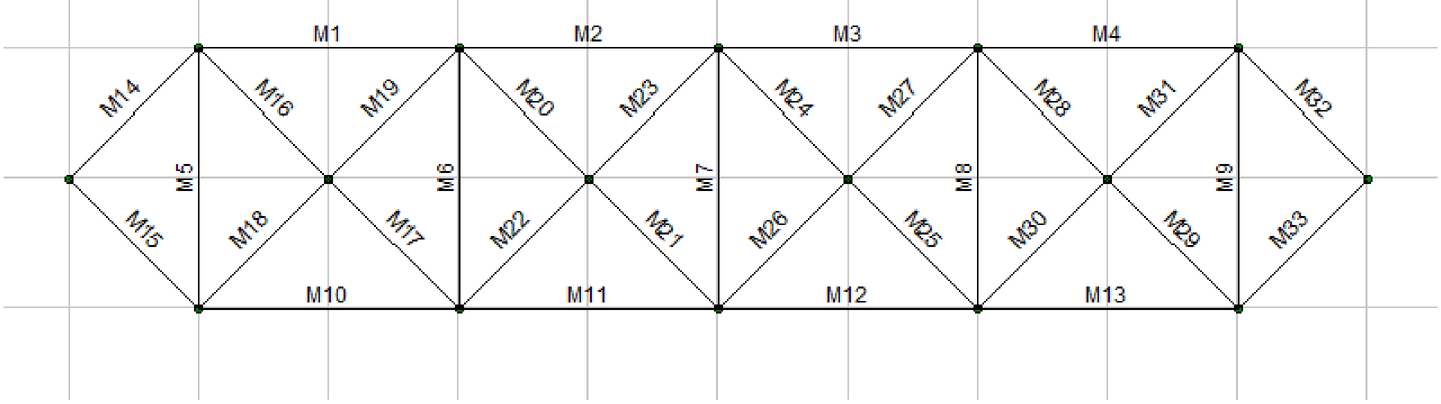
*Each grid square is 0.5 m x 0.5 m: Total Span 5 m

Member Axial Forces (kN)(Tension (+), Compression (-))
Computer Results: First Order Linear Elastic Analysis



*Each Grid Square is 0.5 m x 0.5 m, Clear Span = 10 m

MEMBER LABELING LAYOUT



Member Label	Axial Forces From First Stage (kN)(1)	Axial Forces From Second Stage (kN)(2)	Sum of Axial Forces (1+2)(kN)	Axial Forces From Software (kN)	Absolute Difference of Axial Forces (kN)	Percent Error Per Member (%)	SAFER or NOT
M1	0	-2	-2	-1.905	0.095	4.99	SAFER
M2	0	-3	-3	-2.915	0.085	2.92	SAFER
M3	0	-3	-3	-2.915	0.085	2.92	SAFER
M4	0	-2	-2	-1.905	0.095	4.99	SAFER
M5	0.75	-1.25	-0.5	-0.405	0.095	23.46	SAFER
M6	2.25	-2.75	-0.5	-0.32	0.18	56.25	SAFER
M7	2.75	-3.25	-0.5	-0.33	0.17	51.52	SAFER
M8	2.25	-2.75	-0.5	-0.32	0.18	56.25	SAFER
M9	0.75	-1.25	-0.5	-0.405	0.095	23.46	SAFER
M10	2	0	2	2.095	0.095	4.53	N. SAFE
M11	3	0	3	3.085	0.085	2.76	N. SAFE
M12	3	0	3	3.085	0.085	2.76	N. SAFE
M13	2	0	2	2.095	0.095	4.53	N. SAFE
M14	-0.884	-0.884	-1.768	-1.768	0	0.00	EQUAL
M15	0.884	0.884	1.768	1.768	0	0.00	EQUAL
M16	-0.884	1.945	1.061	0.927	0.134	14.46	SAFER
M17	-0.884	1.945	1.061	0.927	0.134	14.46	SAFER
M18	-1.945	0.884	-1.061	-1.195	0.134	11.21	N. SAFE
M19	-1.945	0.884	-1.061	-1.195	0.134	11.21	N. SAFE
M20	-1.945	2.298	0.353	0.233	0.12	51.50	SAFER
M21	-1.945	2.298	0.353	0.233	0.12	51.50	SAFER
M22	-2.298	1.945	-0.353	-0.474	0.121	25.53	N. SAFE
M23	-2.298	1.945	-0.353	-0.474	0.121	25.53	N. SAFE
M24	-2.298	1.945	-0.353	-0.474	0.121	25.53	N. SAFE
M25	-2.298	1.945	-0.353	-0.474	0.121	25.53	N. SAFE
M26	-1.945	2.298	0.353	0.233	0.12	51.50	SAFER
M27	-1.945	2.298	0.353	0.233	0.12	51.50	SAFER
M28	-1.945	0.884	-1.061	-1.195	0.134	11.21	N. SAFE
M29	-1.945	0.884	-1.061	-1.195	0.134	11.21	N. SAFE
M30	-0.884	1.945	1.061	0.927	0.134	14.46	SAFER
M31	-0.884	1.945	1.061	0.927	0.134	14.46	SAFER
M32	-0.884	-0.884	-1.768	-1.768	0	0.00	EQUAL
M33	0.884	0.884	1.768	1.768	0	0.00	EQUAL

At the left, there is a spreadsheet which shows the numerical results. All the approximations that go on the safer side is not a big issue other than economic disadvantage if the load applied is high. I'm focusing on the not safe values. Most of the not safe forces have a low percentage error and this error can be compensated by safety factors used in design. But if I focus on members 22, 23, 24 and 25. I see an error of 25.53%. But these members are the ones with the smallest force value. So here again the minimum requirements of the design code used will govern. Therefore, this "specific" structure can be designed by two-stage method although I don't recommend this in 2018. But can it be done? Yes.

After solving example 1, I noticed that for most of the time I get the same results. My results for example 1 at the paper differ at some points. Those can be seen below. Green circles represent not very important mismatches. Green circles with a red star mark are significant mismatches. In this example, all the only green mismatches are due to roundoff which is not very significant. Mismatch number 5, 6, 7, 8 and 15, 16, 21, 22 is because of a calculation error or too much rounding from authors part while doing the calculations. Because of this difference, significant mismatches 29, 30, 31, 32, 33, 34, 35, 36 happen. Mismatch 25 and 26 are the most significant for this example and I think the author or the editor copied the shape from above and forgot to change those values.

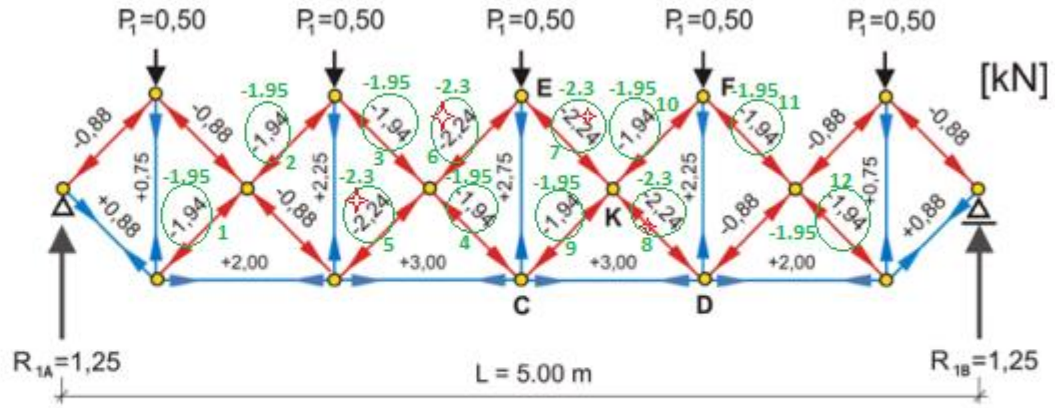


Figure 3. Arrangement of force values calculated in the first stage

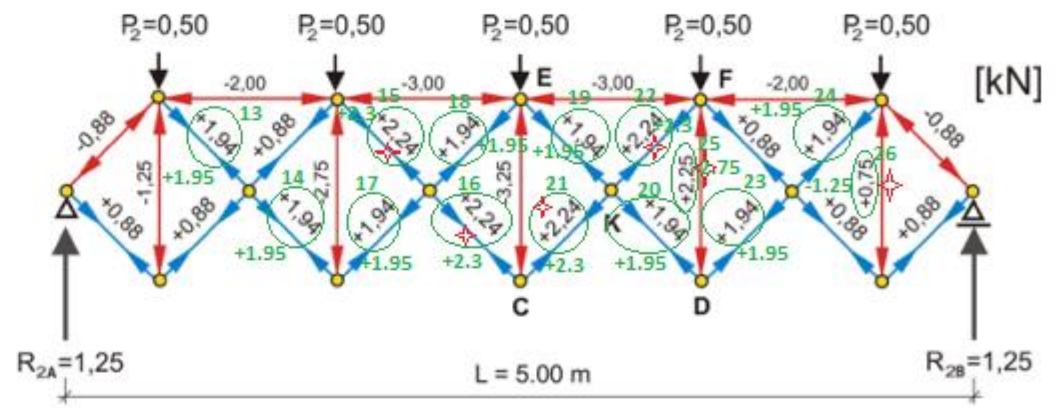


Figure 4. Arrangement of force values calculated in the second stage

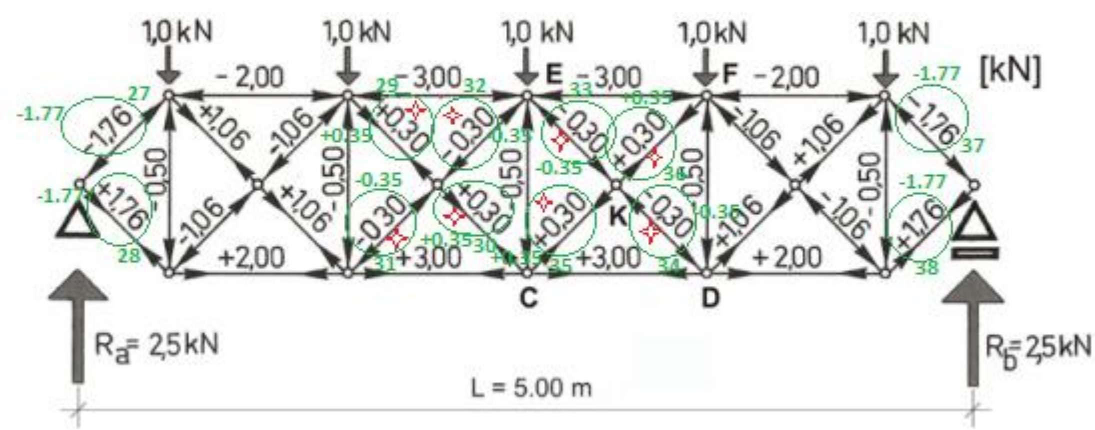


Figure 5. Values of forces obtained as a result of appropriate application of principle of superposition in the proposed two-stage method of calculation