American Journal of Mechanical Engineering, 2017, Vol. 5, No. 6, 345-349
Available online at http://pubs.sciepub.com/ajme/5/6/23

DOI:10.12691/ajme-5-6-23

Strength Analysis of Steel Support Structure

Miroslav Pástor, František Trebuňa, Pavol Lengvarský*

Department of Applied Mechanics and Mechanical Engineering, Faculty of Mechanical Engineering,
Technical University of Košice, Košice, Slovakia
*Corresponding author: pavol.lengvarsky@tuke.sk

Abstract In this paper a strength analysis of a steel support structure is investigated. The steel support structure is designed as a truss with L-shaped profiles. The analysis is performed for three types of load variants. The first two variants take into account current state of the structure and the third variant deals with state after connection of new equipment. The load in the first variant takes into account the weight of the steel support structure and the weight of the roofing. The second variant is expanded by the weight of the snow calculated according to the standards and the third variant is expanded by the weight of the ventilation system. For the all variants, the axial forces and the axial stresses in the truss are computed. It is clear from the results that the steel support structure without fracture and exceeding the yield strength of the material.

Keywords: *strength, truss, finite element method, stress, axial force, axial stress*

Cite This Article: Miroslav Pástor, František Trebuňa, and Pavol Lengvarský, "Strength Analysis of Steel Support Structure." *American Journal of Mechanical Engineering*, vol. 5, no. 6 (2017): 345-349. doi: 10.12691/ajme-5-6-23.

1. Introduction

Start of development of thin-walled structures (beams) can be traced back to the 19th century, due to the rapid development of the industry, it was necessary to create large-scale buildings, structures and facilities, when conventional design methodologies together with traditional materials could not be always applied. Various types of beams can be made from structural elements, from full to various hybrid beams. The use of a specific beam depends on many static, structural, manufacturing factors and requirements. The current trend is to use different types and shapes of beams and create from them a complex truss. Nowadays, the trend of optimal utilization of design and material is used for mass and cost reduction. This creates opportunities for new ideas of design structural elements. The beams can be used as part of roof construction. The beams are used in the roof construction for they have good stiffness and the ability to carry large loads [1-10].

In this paper the strength analysis of roof structure is investigated. The roof structure is loaded by the three variants of load. The analysis of the structure is performed to verify the current state and for the future installation of the ventilation system. The strength analysis is solved using the finite element method. The steel beams are modeled as rod elements with given cross-sectional areas and lengths according to the dimensions of the real structure. For the all variants of load, the axial forces and axial stresses are calculated, which ones do not exceed the yield strength of the material of the roof structure.

2. Roof Structure

Figure 1. Roof structure

Figure 2. Supporting steel pillars of the steel roof structure

Figure 3. Pair of the rolled L profiles

Figure 4. Riveted connection of the rods

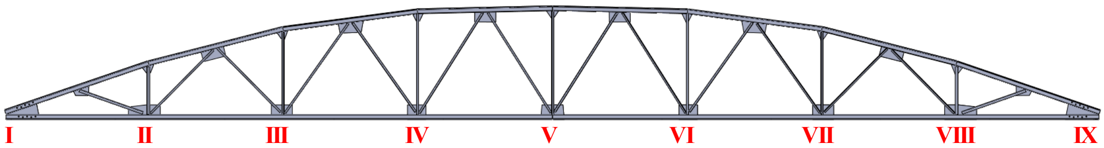


Figure 5. Scheme of the steel support structure

The steel support structure is made from truss profiles L 50x50x6, L 70x70x8, L 120x120x12 (Figure 1) placed on the supporting pillars at the distance 6 m (Figure 2). Each rod forms a pair of rolled L profiles (Figure 3), which are riveted to the steel joint plate by three rivets (Figure 4). Based on the drawing documentation, the roof structure is a truss system with rods loaded by the axial tension or compression forces.

The model of the steel support structure with the designation of the selected steel joint plates is shown in Figure 5.

3. Roof Structure

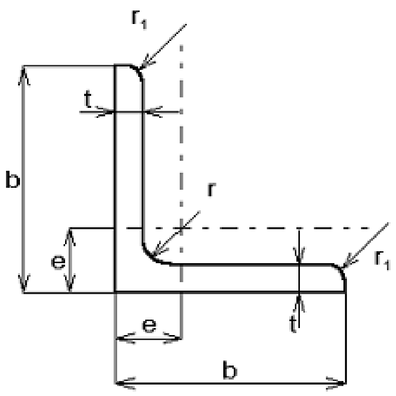


Figure 6. Cross section of L profiles

The roof structure is made from L profiles with cross section shown in Figure 6 and basic dimensions given in Table 1. The given profiles are loaded only by the axial forces that arise from the load. The axial forces of the rods are obtained using numerical modeling.

Table 1. Basic dimensions of L profiles

Parameters	Profile		
	L 50x50x6	L 70x70x8	L 120x120x12
b (mm)	50	70	120
t (mm)	6	8	12
r (mm)	7	10	13
r_1 (mm)	3.5	5	6.5
e (mm)	14.4	20.0	33.9
A (mm^2)	569	1226	2750
m (kg/m)	4.47	8.37	21.6

3.1. Numerical Modeling

In solving tasks of the steel roof structures the boundary conditions are considered as pinned support on the one end and roller support on the second end The model with the applied boundary conditions and the applied forces is shown in Figure 7.

The CAD model of the support structure for the computation of the axial forces and stresses is shown in the Figure 8.

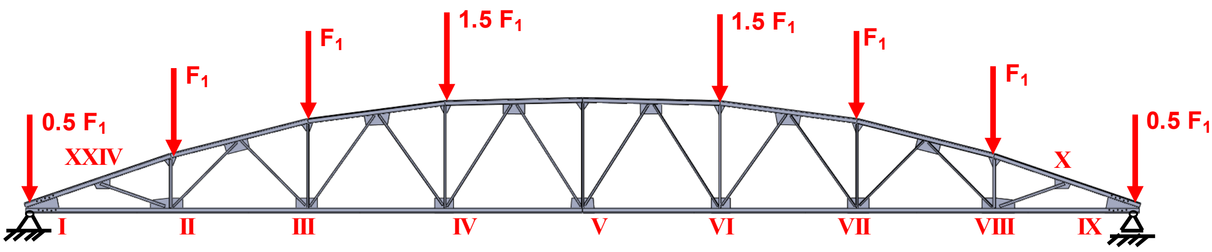


Figure 7. Applied boundary conditions and loads on the roof structure

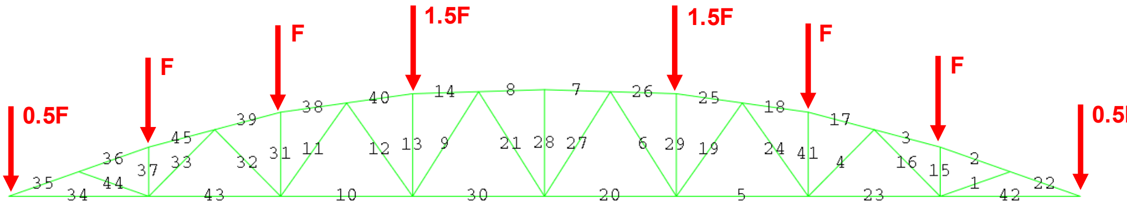


Figure 8. Finite element model of the roof structure

The forces in the model corresponds to the load applied to the area defined by the two joints of the adjacent vertical rods and the distance between the two truss. The numbering of the rods is shown in the Figure 8. For the computation, the cross section areas are defined using Table 1. The CAD model of the roof structure is made by truss elements, where the one element is represented by the pair of L profiles. The material 11 373 (S235JG) is used for the computation of the roof structure. The yield strength of this material is equal 235 MPa and tensile strength is equal 360 MPa.

Figure 9. Diagram example

The load forces are not applied in the middle of the roof structure, ones taking into account the skylight in the middle (Figure 9).

The three variants of the load are applied to the finite element model.

Variant A: the load consists from the weight of the steel roof structure and the weight of the roofing: $F = 32$ kN + 64 kN = 96 kN.

Variant B: the load consists from the weight of the steel roof structure, the weight of the roofing and weight of the snow or ice coating: $F = 32$ kN + 64 kN + 160 kN = 256 kN. The standard Eurocode 1 is used to calculate the weight of the snow and ice coating [11].

Variant C: the load consists from the weight of the steel roof structure, the weight of the roofing and weight of the snow or ice coating: $F_1 = 32$ kN + 64 kN + 160 kN = 256 kN, and the load from the weight of the ventilation system $F_2 = 2$ kN applied to joins with numbers *II*, *IV* and *V* (Figure 10).

Finally, the static analysis of the roof structure is performed and the results of the axial forces and the axial stresses are obtained.

The fields of axial stresses for the all rods and for the all variants are shown in Figure 11. The obtained numerical values of the all results are given in Table 2. The maximum axial tension or compression stresses in the rods are not higher than 60 MPa and ones do not cross the material yield strength equal to 235 MPa.

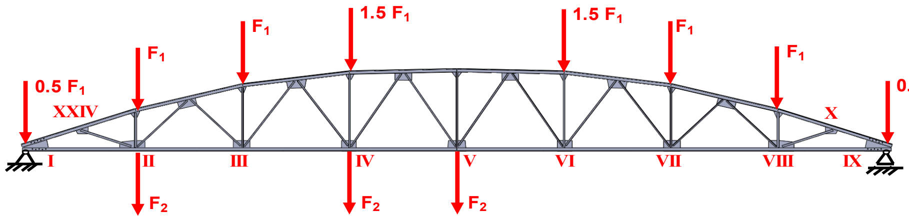
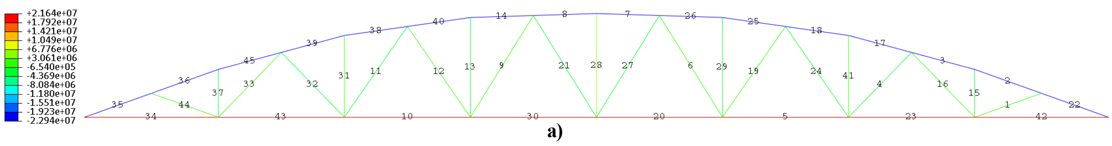
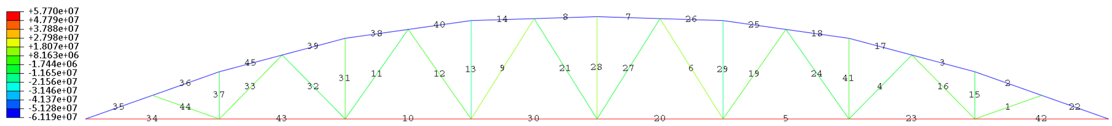


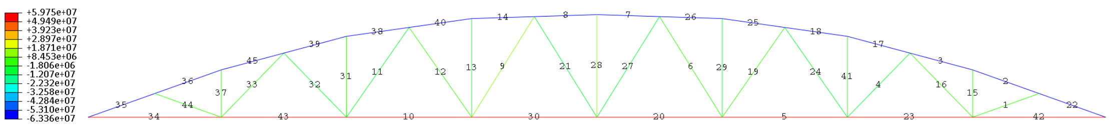
Figure 10. Applied boundary conditions and forces for the variant C



a)



b)



c)

Figure 11. Fields of the axial stresses for a) variant of load A, b) variant of load B and c) for variant of load C (MPa)

Table 2. Computed results of the axial stresses and forces in the rods

No. of beam	Length of beam (m)	Axial stress Variant A (MPa)	Axial stress Variant B (MPa)	Axial stress Variant C (MPa)	Axial forces Variant A (N)	Axial forces Variant B (N)	Axial forces Variant C (N)
1	1.8	0.00	0.00	0.00	0	0	0
2	1.8	-22.94	-61.19	-62.29	-126194	-336518	-342574
3	1.65	-22.39	-59.70	-60.77	-123127	-328337	-334246
4	2.3	-1.38	-3.67	-2.74	-1567	-4179	-3116
5	3.2	21.39	57.03	58.35	117626	313671	320934
6	3	2.10	9.69	6.34	2386	11028	7215
7	1.6	-21.19	-55.75	-57.58	-116519	-306611	-316693
8	1.6	-21.19	-55.75	-57.58	-116519	-306611	-316693
9	3	2.10	9.69	8.53	2386	11028	9708
10	3.2	21.39	57.03	58.88	117626	313671	323813
11	2.8	-2.06	-5.50	-5.30	-2346	-6256	-6035
12	2.8	1.69	4.51	4.35	1924	5130	4949
13	2.5	-3.16	-11.90	-9.03	-3595	-13537	-10272
14	1.6	-21.57	-57.51	-59.42	-118618	-316314	-326819
15	1.2	-0.85	-2.28	-1.78	-1821	-4857	-3793
16	2.3	2.35	6.27	4.68	2677	7140	5323
17	1.65	-21.91	-58.44	-59.66	-120528	-321406	-328120
18	1.6	-21.39	-57.03	-58.23	-117634	-313691	-320243
19	2.8	1.69	4.51	4.77	1924	5130	5434
20	3.2	21.36	56.58	58.22	117490	311216	320226
21	3	-2.02	-9.32	-8.20	-2294	-10604	-9335
22	1.8	-22.94	-61.19	-62.29	-126194	-336518	-342574
23	3.2	21.35	56.93	58.06	117416	313108	319309
24	2.8	-2.06	-5.50	-5.82	-2346	-6256	-6626
25	1.6	-21.77	-58.05	-59.50	-119727	-319271	-327249
26	1.6	-21.57	-57.51	-58.95	-118618	-316314	-324218
27	3	-2.02	-9.32	-6.10	-2294	-10604	-6937
28	2.6	3.42	15.79	13.87	3887	17964	15784
29	2.5	-3.16	-11.90	-9.28	-3595	-13537	-10556
30	3.2	21.36	56.58	58.45	117490	311216	321500
31	2.05	2.67	7.11	7.07	3036	8095	8042
32	2.3	-1.38	-3.67	-3.83	-1567	-4179	-4359
33	2.3	2.35	6.27	6.54	2677	7140	7446
34	3.4	21.64	57.70	59.75	119000	317334	328623
35	1.8	-22.94	-61.19	-63.36	-126194	-336518	-348490
36	1.8	-22.94	-61.19	-63.36	-126194	-336518	-348490
37	1.2	-0.85	-2.28	-1.55	-1821	-4857	-3306
38	1.6	-21.39	-57.03	-58.82	-117634	-313691	-323493
39	1.65	-21.91	-58.44	-60.26	-120528	-321406	-331449
40	1.6	-21.77	-58.05	-59.98	-119727	-319271	-329874
41	2.05	2.67	7.11	6.71	3036	8095	7640
42	3.4	21.64	57.70	58.74	119000	317334	323044
43	3.2	21.35	56.93	58.80	117416	313108	323399
44	1.8	0.00	0.00	0.00	0	0	0
45	1.65	-22.39	-59.70	-61.82	-123127	-328337	-340019

4. Conclusion

The strength analysis of steel roof structure of industry hall was analyzed in this paper. The structure was made from steel L profiles, which were interconnected steel joint plates. The model of the roof construction was made by CAD program and the three variants of the loads were applied to the structure. The first variant consisted from the weight of the steel structure and the weight of the roofing. The second variant also took into account effects from the weight of the snow and the third one took into account the weight of the ventilation systems. For the all variants the static analysis was performed using the finite element method, where the roof structure was made by the truss elements and the boundary conditions were applied. The results of the stress analysis were shown in the form of graphs and the values of the axial stresses and forces were given in the table. The all obtained data of the axial stresses were smaller than the material yield strength of the roof structure. The design of the roof satisfies for the all load variants.

Acknowledgements

This research was supported by a grant from the Slovak Grant Agency VEGA No. 1/0731/16 and VEGA No. 1/0751/16.

References

[1] Fogg, B.J, Persuasive technology: using computers to change what we think and do, Morgan Kaufmann Publishers, Boston, 2003, 30-35.

[2] Hirsh, H., Coen, M.H., Mozer, M.C., Hasha, R. and Flanagan, J.L, “Room service, AI-style,” IEEE intelligent systems, 14 (2). 8-19. Jul.2002.

[3] T. Eckes, The Developmental Social Psychology of Gender, Lawrence Erlbaum, 2000. [E-book] Available: netLibrary e-book.

[4] Meriam, J.L. and Kraige, L.G., Engineering Mechanics: Statics, Wiley, Texas, 2011.

[5] Cherchuk, R.N., Method of Joints (Easy Way), Amazon Digital Services LLC, 2014, [E-book] Available: Amozon.com.

[6] Bocko, J. and Delyová, I., Statics, Technical University of Košice, Košice, 2015.

[7] Togan, V., Durmaz, M. and Daloglu, A., “Optimization of roof trusses under snow loads given in Turkish Codes,” Engineering Structures, 28, 1019-1027, 2006.

[8] Ronald, W., “Structural performance of light-frame truss-roof assemblies,” in Proceedings of the international engineering conference, Louisiana State University, 263-268.

[9] Lengvarský, P. and Bocko, “The Static Analysis of the Truss,” American Journal of Mechanical Engineering, 4 (7). 440-444. Dec.2016.

[10] Pástor, M., Bocko, J., Kula, T., and Roszkos, C.S. “Possibilities of Optimizing the Shape and Geometry of Castellated Beams Using Numerical and Experimental Modeling,” American Journal of Mechanical Engineering, 4 (7). 357-362. Dec.2016.

[11] STN EN 1991-1-3: Eurocode 1. Actions on structures. Part 1-3: General actions. Snow loads.