COMPARATIVE STATIC ANALYSIS OF LATTICES BEAMS MADE OF WOODEN AND METAL MATERIAL TO ESTABLISH THE LIMITS OF USE FOR THE SAME LOAD VALUES

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RESEARCH ARTICLE

Abstract

Considering the wide field of use of lattice beams, starting from the roofs of houses to bridges and electricity transmission systems, the current work is intended to be and present a comparative static analysis of a structure made of wood material - oak, and steel. This follows the stability of some limits of use of these types of structure depending on the elastic and mechanical properties of the materials. It is also known that the realization of metal structures involves a higher energy consumption than those made of wooden material. Thus, from an economic, as well as energetic point of view, the analysis carried out by the author allows the stabilization of the values of external loads until the use of wood material ensures the safe operation of the structures. From the dimensional point of view, of the adopted geometry and the method of loading the structure with lattices, the similarity is maintained both for the wooden material and for the steel.

Keywords: lattice beam; nodes; displacements; tensile forces.
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INTRODUCTION

In the vast majority of scientific works up to now, the topic related to the analysis of beams with lattices has been a challenge mainly from the point of view of adapting their geometry according to the position in the final structure, the way of loading and supporting. It is known that at the present time the studies have presented and solved extensively all the previously mentioned challenges.

In the current conditions, the analysis on these landings is no longer relevant except for certain specific cases of loading and ensuring geometric non-deformability. The current work is based on the static analysis of the same beam-type structure with lattices, taking into account the geometry, its loading method and the supporting method (Soare, 1999). The difference in terms of obtaining these data obtained by the two types of materials from which the beam is considered to be made, namely: wooden material and steel.

Taking into account the daily realities, the problem of comparative analysis that was addressed and that was wanted to be solved by the author, constitutes a challenge that needs to be solved on several levels.

One of the plans is strictly related to the determination of the mechanical characteristics that are determined from the calculations for each type of material - stresses, displacements, efforts, reactions (Bors, 2003) - and the second level on which the analysis is aimed is the energetic one. In the current conditions related to the energy crisis, the problem of saving energy in all industrial branches is of allmost importance. The mechanical analysis carried out with the data presented is in close correlation with the energetic one because, through the results obtained by the author in the current paper, certain limits of using a less energy-consuming material such as wood compared to steel are presented.

MATERIAL AND METHOD

In the present work, the materials that were taken into account for the lattice beam studied are: the wooden material is called oak beam and steel. From the beginning, the same geometry and the same dimensional values were considered for the beam elements with lattices (Martian, 1999). It was also considered the simultaneous action of three forces concentrated on nodes 1, 3 and 5, having modules of 300 [KN] – nodes 1 and 3 and 200 [KN] on node 2.

For the case of the wooden material, the following physical-mechanical characteristics were considered

ρ =700 [Kg/mc]- oak density;

E=11500[N/mm2]– longitudinal modulus of elasticity;

ν=0.372 – Poisson's ratio.

For the steel material, they considered the following physical-mechanical characteristics

ρ =7860 [Kg/mc] - oak density;

E=210000[N/mm2]–longitudinal modulus of elasticity;

ν=0.3 – Poisson's ratio

Analytical mechanical calculation of lattice beams is based on the known methods - the method of sections or the method of isolation of nodes (Martian, 1999), (Ille, 1983). By applying these known analytical methods, the sectional stresses in the system bars and the stresses are determined. The displacements of the points in the transverse sections of the beam bars are determined using one of the known methods - the direct integration method (Fetea, 2021), Mohr's method or the initial parameters method (Barsan, 1979).

The method used is not a classic analytical one that involves a laborious mathematical calculation, but is by applying one of the aforementioned, by using calculation programs dedicated to mechanical calculations using the LISA educational software (Ghinea, 2004) . The use of the mentioned program leads to the idea of the fact that in the present work the mathematical apparatus used is not of interest, but its application to establish, based on the results obtained, the limits of use of the two dimensionally equal structures and having the same loads, but different materials.

RESULTS AND DISCUSSIONS

Next, based on the modeled structure with the help of Lisa educational software, the geometry of the structure and the mechanical parameters for each of the materials considered separately are presented. Taking into account the similar way of geometric, two-dimensional conception and loading of the structure, the following values were obtained.

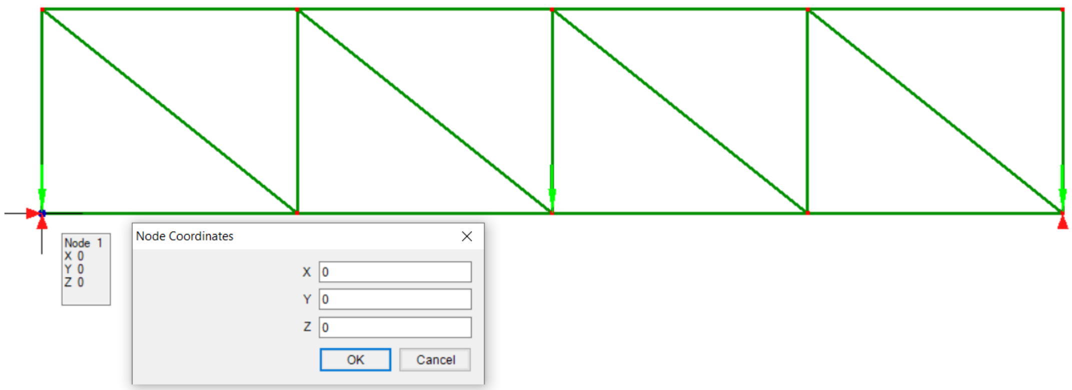

Figure.1 **Wood lattice beam**

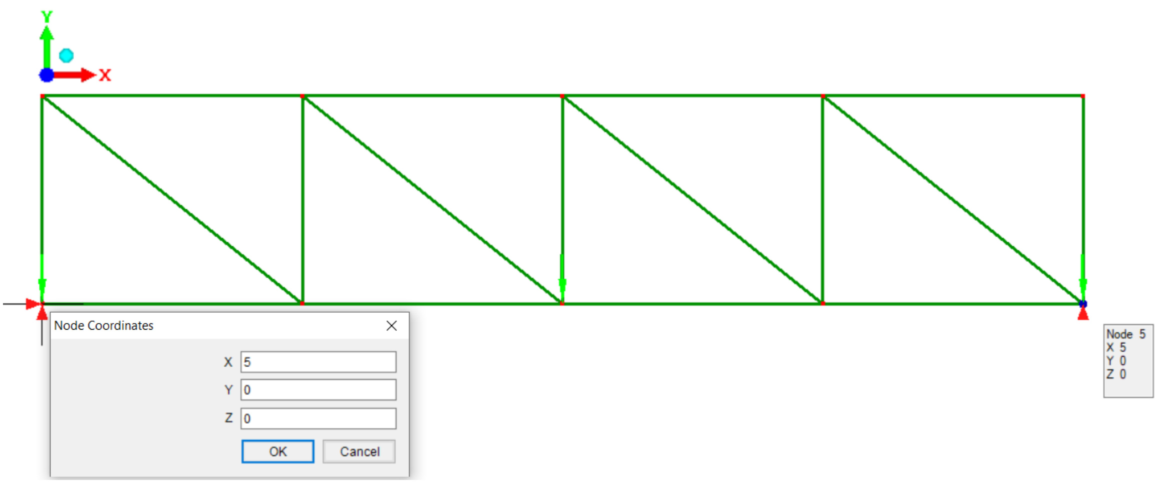

Figure. 2 **Steel lattice beam**

RESULTS AND DISCUSSIONS

1. For the structure made of wooden material.

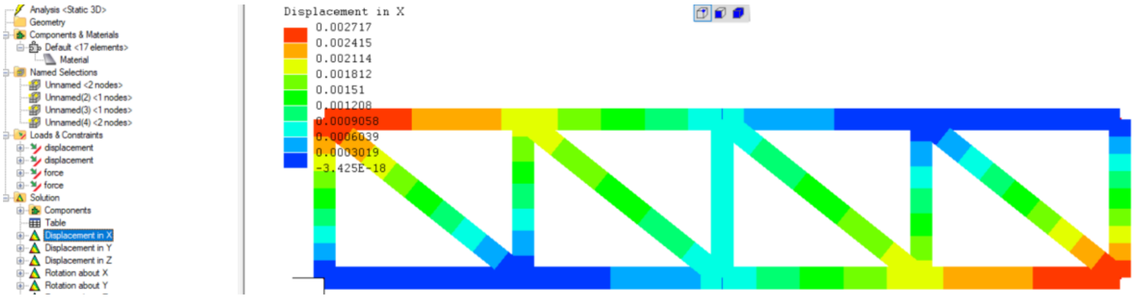

Figure. 3 **Displacements along X axes for wood lattice beam**

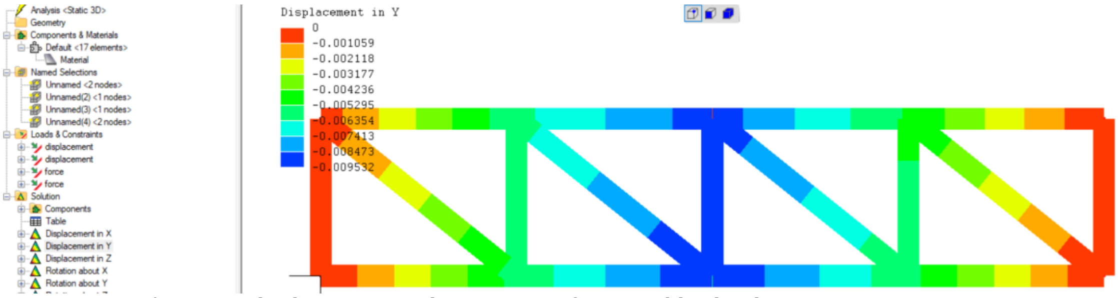

Figure. 4 **Displacements along Y axes for wood lattice beam**

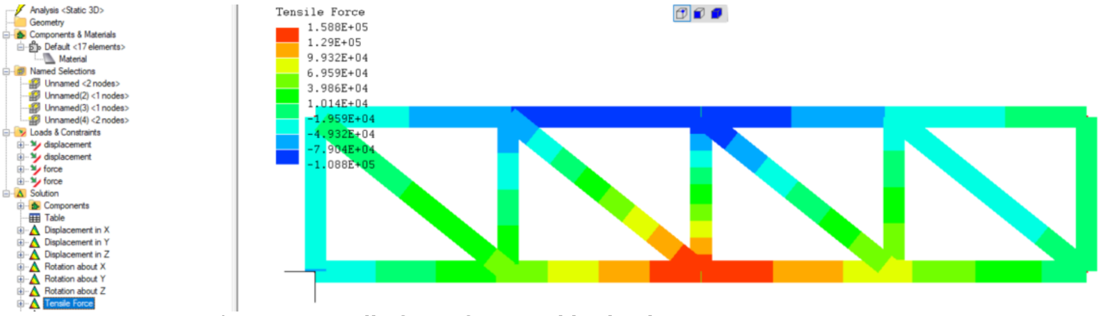

Figure. 5 **Tensile force for wood lattice beam**

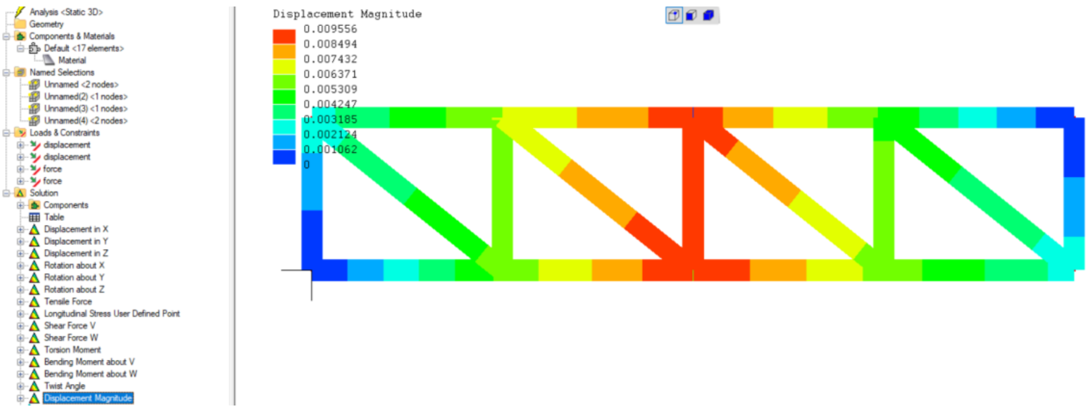

Figure. 6 **Displacements magnitude for wood lattice beam**

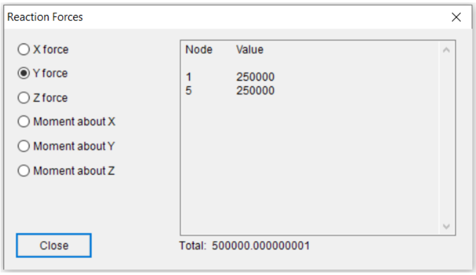

Figure. 7 **Reactions forces for wood lattice beam**

kinematic and static parameters for the wooden structure Table 1

Node	Displacement in X	Displacement in Y	Tensile Force	Displacement Magnitude
1	0	0	-50000.0000000003	0
2	-1.16229248448008E-18	-0.00561500063678498	46269.5264839553	0.00561500063678498
3	0.000679347826086957	-0.00953163170835257	158769.526483956	0.00955581061409659
4	0.00203804347826087	-0.00561500063678499	78730.4735160451	0.00597342894578796
5	0.00271739130434783	0	-11692.7019786072	0.00271739130434783
6	0.00271739130434783	-0.000434782608695654	-21640.6313547263	0.00275195410895048
7	0.00203804347826087	-0.00604978324548064	-78730.473516045	0.00638384668805415
8	0.000679347826086956	-0.00909684909965691	-108769.526483956	0.00912218049650071
9	-3.425043973191E-18	-0.00518021802808933	-46269.5264839555	0.00518021802808933
10	-3.425043973191E-18	0	0	3.425043973191E-18

2. For steel structure.

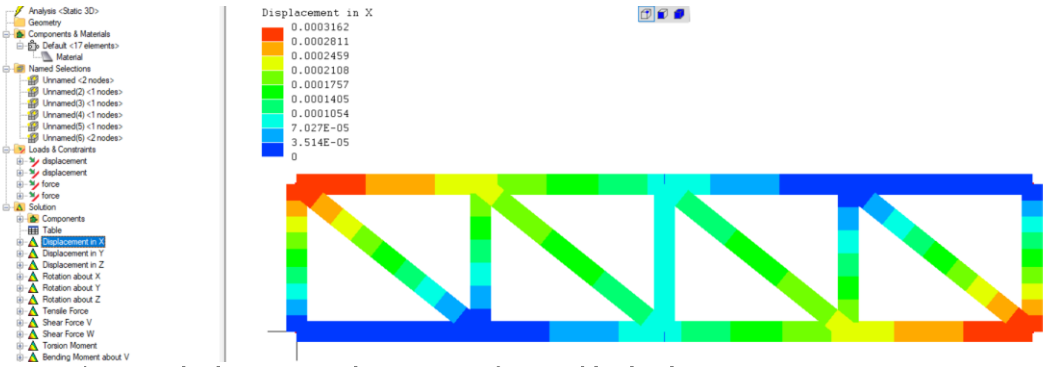

Figure 8 **Displacements along X axes for steel lattice beam**

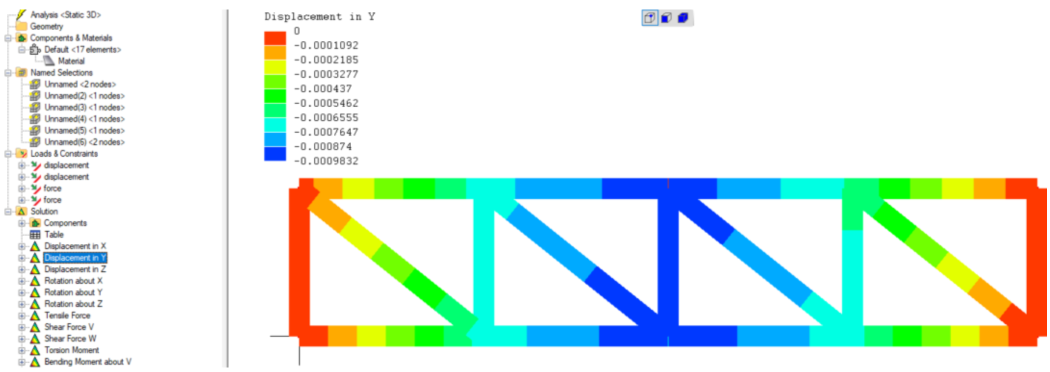

Figure. 9 **Displacements along Y axes for steel lattice beam**

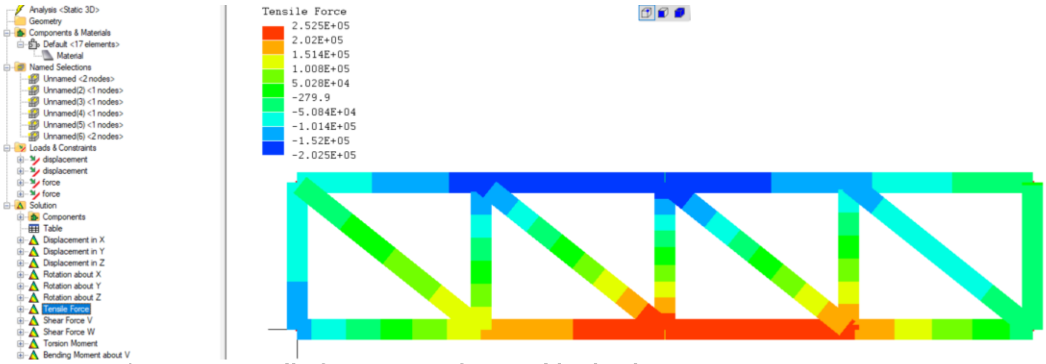

Figure. 10 **Tensile forces axes for steel lattice beam**

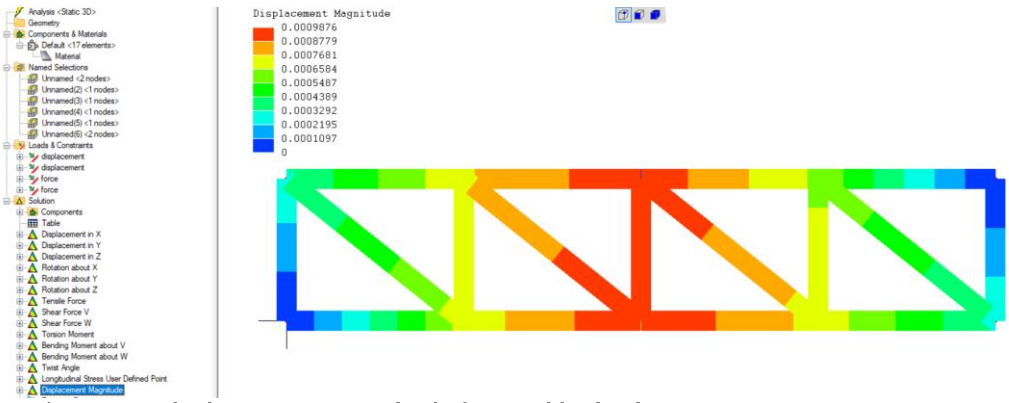

Figure. 11. **Displacements magnitude for steel lattice beam**

kinematic and static parameters for the steel structure Table 2

Node	Displacement in X	Displacement in Y	Tensile Force	Displacement Magnitude
1	0	0	-125000	0
2	6.82321593405864E-20	-0.000698965860988417	153173.816209888	0.000698965860988417
3	9.30059523809523E-05	-0.000983202503002831	252519.526483955	0.000987591650981983
4	0.000223214285714285	-0.000698965860988417	209980.473516044	0.000733742388154192
5	0.000316220238095238	0	-29231.7549465176	0.000316220238095238
6	0.000316220238095238	-5.95238095238094E-05	-54101.5783868155	0.000321773713782272
7	0.000223214285714286	-0.000722775384797941	-172480.473516045	0.000756458111343087
8	9.30059523809525E-05	-0.000959392979193307	-202519.526483955	0.000963890551724467
9	1.45257473603225E-19	-0.000639442051464607	-115673.816209888	0.000639442051464607
10	1.45257473603225E-19	0	0	1.45257473603225E-19

CONCLUSIONS

Following the results obtained from the application of the Lisa numerical calculation program, one can proceed to a precise interpretation of them (Ghinea, 2004). From tables 1 and 2 presented in the previous sub-chapter, it is noted that the static analysis of the two types of structures, which are geometrically identical and different in terms of materials, allows the interpretation of the kinematic parameters (the displacements along the X and Y axes, the maximum displacement and the static parameter given by the axial force that appears in the transverse sections of the bars. The Lisa program allows the interpretation of the results both in the nodes of the structure and in the elements, depending on the calculation method used to create the program. The results that were presented in the paper are those from the application of the node isolation method.

The following are noted:

1. Due to the load symmetry of the structures, the displacement values along the X and Y axes for both studied structures are mirrored from node 3 to node 8.

2. Regarding their maximum values, it is noted that they are recorded in nodes 5 and 6 for both the wooden and the metal structure. For the metal structure, the displacement value along the X axis is 0.3 [mm], and the wooden one is approximately 2.7 [mm]. Therefore, the displacement in the wooden structure for the same load is approximately 9 times greater. In the end nodes, the displacements on both structures can be considered as zero.
3. The displacements along the Y axis for both structures are larger. The maximum values are recorded in nodes 3 and 8. For the wooden structure it is about 9.5 [mm], and for the metal structure about 1 [mm]. Taking into account the maximum permissible displacement values for both structures, for the wooden structure we are at the acceptable upper limit
4. Regarding the maximum values of the axial forces, they are recorded in nodes 3 of each structure, being approximately 159[KN] for the wooden structure and 252{KN] for the metal one. It is noted that the static parameters do not have the same kinematics. Therefore, the metal structure can take an axial force only 63% higher than the wooden one because the static parameters do not have the same kinematics. Therefore, the metal structure can take an axial force only 63% higher than the wooden one.

From the comparative static analysis carried out in this work, it is noted that from a mechanical point of view certain limits can be established for the safe use of wooden structures. Of course, the external load values will always be taken into account as well as the location where the structure will be operated and incorporated.

Analyzing from the energy point of view, it was found that more and more countries aim to gradually replace metal and concrete constructions with wooden structures because, beyond the thermal and ecological advantages, the production of wood for construction consumes tens of times less energy than the manufacture of concrete, steel or bricks. Due to the multiple advantages they have, the production of wooden beams worldwide has seen a permanent increase in the last 40 years.

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