COMPARATIVE MECHANICAL ANALYSIS OF THE BEHAVIOR UNDER STATIC LOADS OF DIFFERENT TYPES OF WOODEN FRAMES

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Abstract

In this scientific work, the author followed the performance of a static study on two different types of frames in terms of support on the ground, but identical in terms of loads with external forces and dimensional values of the component elements, as well as in terms of geometric shape.
All the static and kinematic values obtained in the study carried out by the author for the two frames were determined in the same sections. The analysis was carried out by applying numerical calculation methods and the LISA 8 software. Following this analysis, the values determined for the kinematic and static parameters were presented graphically and tabularly. Finally, the comparative study of the two structures and the analysis carried out on them by the author leads to the determination of the percentage deviations of the maximum values of the mentioned parameters.

Keywords: numerical, method, bending, tensile, forces

INTRODUCTION

In the framework of technological works frequently encountered in practice in the field of constructions, frames are one of the most used structures. The work consists of a particular analysis of statically determined and statically indeterminate wooden frames. As a simplifying hypothesis from which to start in the study and analysis of the obtained results, the isotropy of the material is considered as a physical-mechanical characteristic that will determine the behavior of the structures. The analysis was carried out on two types of identical frames from a geometrical and static point of view, one of which is considered statically determined and the second statically indeterminate.

For a correct evaluation of the behavior of the two structures with regard to the applied static loads, they will be considered to be identical as well as the mode, direction and direction. In this way, it will be possible to make a correct evaluation from the point of view of the static and kinematic characteristics of the two structures.

MATERIAL AND METHOD

Statically determined frames are structures made up of straight and bent bars, which are aimed at ensuring non-deformability and fixation to the ground. Since the external loads can be applied anywhere on the structure, in general, in one section the three efforts take place, namely: the axial effort, the shear force and the bending moment. Drawing the stress diagrams is done in advance knowing the connection forces that arise within the considered supports. The stiffness analysis that can be performed after determining the kinematic and static parameters is based on the application of the direct integration method from the statics of constructions (Soare, 1999).

The statically indeterminate structure considered in the present work by the author, presents a greater number of links than the minimum required in order to ensure geometric undeformability and fixation to the ground. Therefore, the static equilibrium equations are insufficient for studying the state of efforts, the number of additional links representing even the degree of static indeterminacy (Bors I, 2005). The static analysis of the indeterminate frame is based on the results obtained by the application of Veresciaghin's rules (Ille V 1977), (Ille, Bia, Soare 1983). The static analysis of the determined and indeterminate structures was carried out numerically using the LISA 8 calculation program (Ghinea, Fireteanu. 2004). The numerical method applied by the program is the finite element method, which is based on the theory of elasticity and plasticity (Martian, 1999).

The first statically determined structure considered in the work is a frame consisting of a pillar and a horizontal crossbar. The vertical pole has a length of 4 meters, and the horizontal crossbar has a length of 5 meters. The support was achieved by a fixed support on the free end of the crossbar and a mobile one on the free end of the pillar. The load is considered as a concentrated force with a modulus of 100 KN, acting at the middle of the pillar opening. The statically indeterminate structure is geometrically and statically identical to the statically determined one, the difference being the way it is supported. At the end of the horizontal crossbar we will have a mobile support, and at the lower end of the vertical pillar an embedment.

RESULTS AND DISCUSSIONS

The analysis of the results obtained on the two structures considered in the paper includes the kinematic and static parameters obtained as well as the graphs of the deformed and undeformed structures. For the case of the statically determined structure.

Table 1 and table 2 show the maximum and minimum values for the kinematic and static parameters obtained in the case of the statically determined frame.

Figure 1 and 2 shows the distribution on the cross sections of the axial displacemets along the X and Y axes using the numerical program LISA 8.

Figure 3 shows the distribution on the cross sections of the axial force using the numerical program LISA 8.

Figure 4 shows the distribution on the cross sections of the shear force using the numerical program LISA 8.

Figure 5 shows the distribution on the cross sections of the bending momens using the numerical program LISA 8.

For the case of the statically indeterminate structure.

Table 3 and table 4 show the maximum and minimum values for the kinematic and static parameters obtained in the case of the statically indetermined frame.

Figure 7 and figure 8, shows the distribution on the cross sections of the axial displacemets along the X and Y axes using the numerical program LISA 8, for indetermined frame.

Figure 9 shows the distribution on the cross sections of the axial force using the numerical program LISA 8, for indetermined frame.

Figure 10 shows the distribution on the cross sections of the shear force using the numerical program LISA 8.

Figure 11 shows the distribution on the cross sections of the bending momens using the numerical program LISA 8.

In figure 6 is presented the deformed shape of the structure aunder the static loading for determined frame and in figure 12 for the indetermined frame. Following the numerical analysis performed on the two types of frames that are similar from a geometric point of view, but different from a static point of view, the following can be found.

1. The displacements of the points on the median axes of the structure's bars are different, being smaller for the undetermined static frame;

2. The axial forces, shear forces and bending moments determined from the considered static action have different values, being higher in the case of the static frame determined for the axial force and bending moments and equal in value as regards the shear force (Bârsan, G 2003).

Table 1

Displacements by X,Y Axes for the Determined Static Frame

Minimum displacements	Maximum displacements
0 (X Axes)	9.39 (X Axes)
0.00075 (Y Axes)	-1.064 (Y Axes)

Table 2

Tensile Forces, Shear Forces, Bending Moments for the Determined Static Frame

Tensile forces Shear forces Bending moments	
0 (Minimum values Tensile forces)	40 (Maximum value Tensile forces)
40 (Minimum values Shear forces)	100 (Maximum values Shear forces)
0 (Minimum value Bending Moments)	-200 (Minimum value Bending Moments)

Figure 1 Displacements by X for the determined static frame.

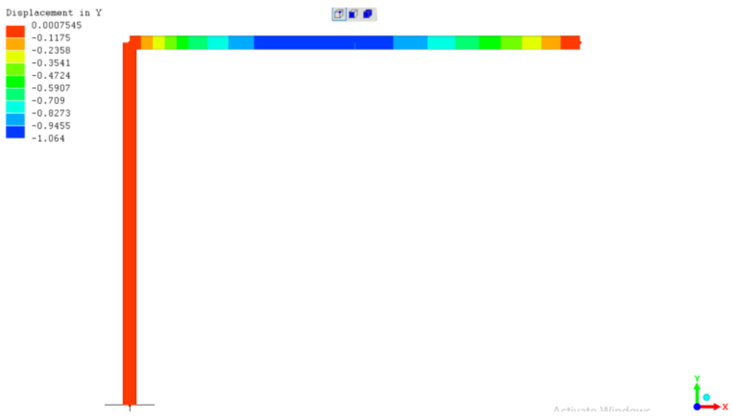

Figure 2 Displacements by Y for the determined static frame.

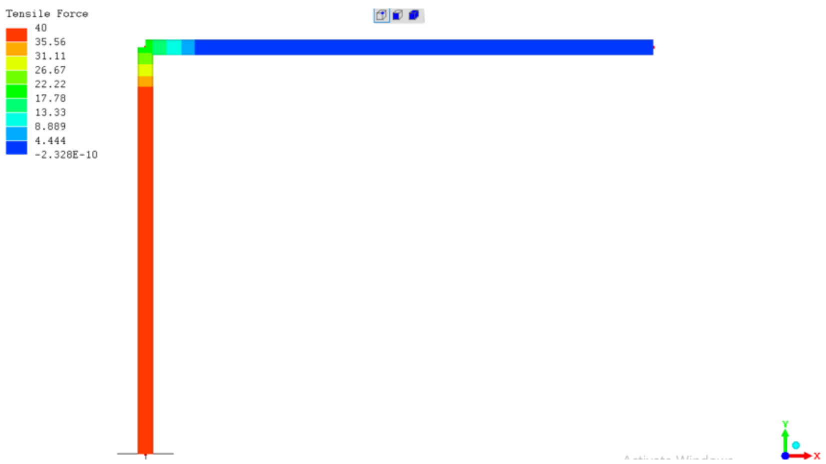

Figure 3 Tensile forces for the determined static frame.

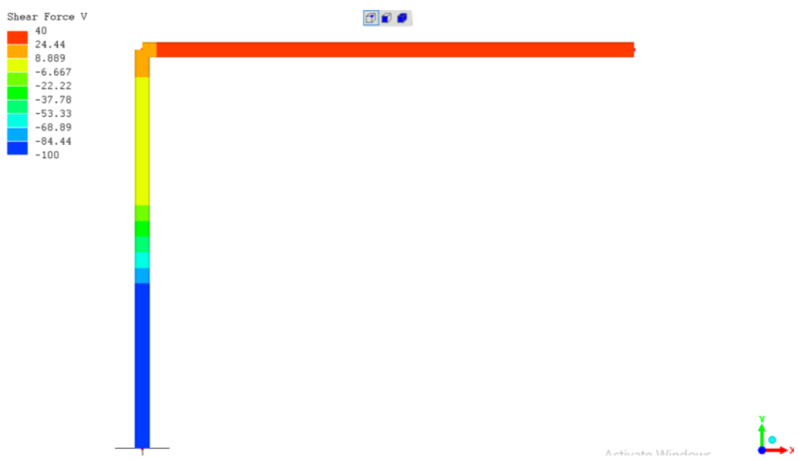

Figure 4 Shear forces for the determined static frame.

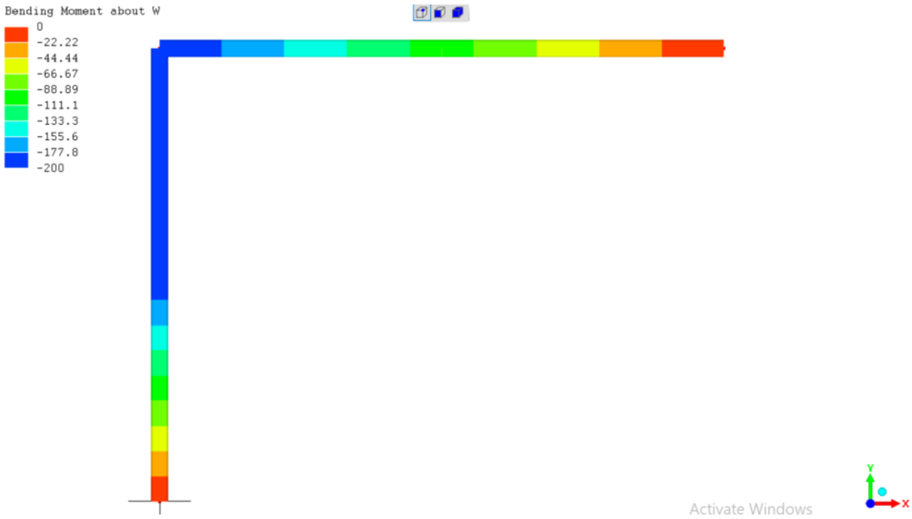

Figure 5 Bending moments for the determined static frame.

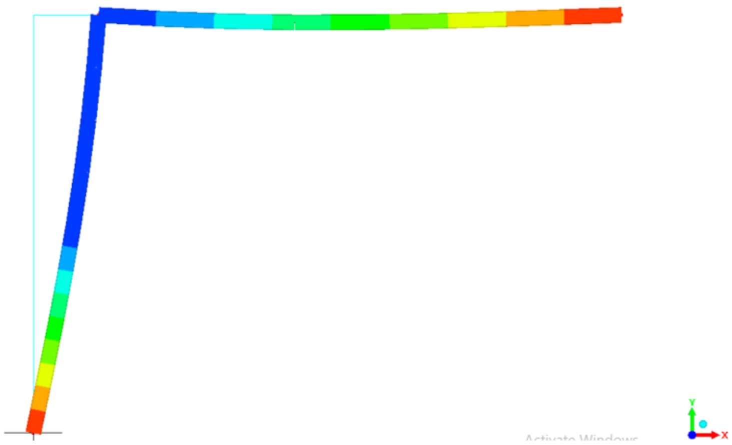

Figure 6. Deformed shape for the determined static frame.

Table 3

Displacements by X,Y Axes for the Indetermined Static Frame

Minimum displacements	Maximum displacements
0 (X Axes)	1.289 (X Axes)
0.000133 (Y Axes)	-0.1877 (Y Axes)

Table 4

Tensile Forces, Shear Forces, Bending Moments for the Determined Static Frame

Tensile forces Shear forces Bending moments	
0 (Minimum values Tensile forces)	7.059 (Maximum value Tensile forces)
7.059 (Minimum values Shear forces)	-100 (Maximum values Shear forces)
-35 (Minimum value Bending Moments)	164.7 (Minimum value Bending Moments)

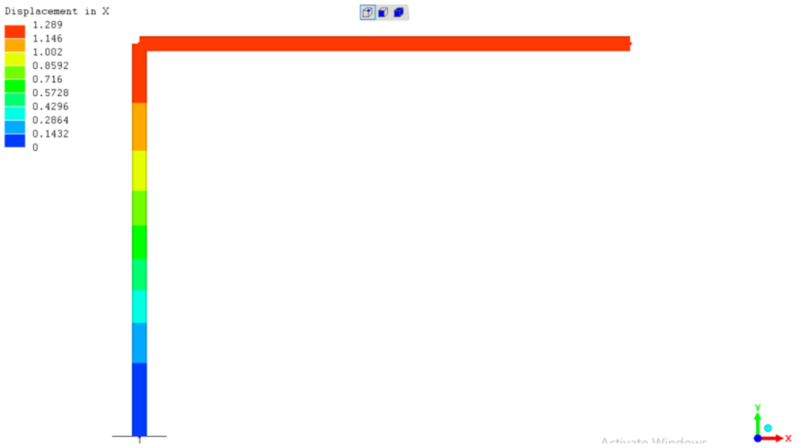

Figure 7 Displacements by X for the indetermined static frame.

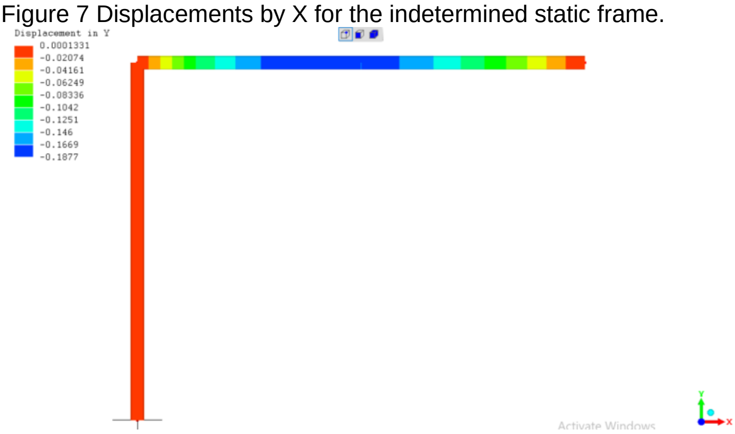

Figure 8 Displacements by Y for the indetermined static frame.

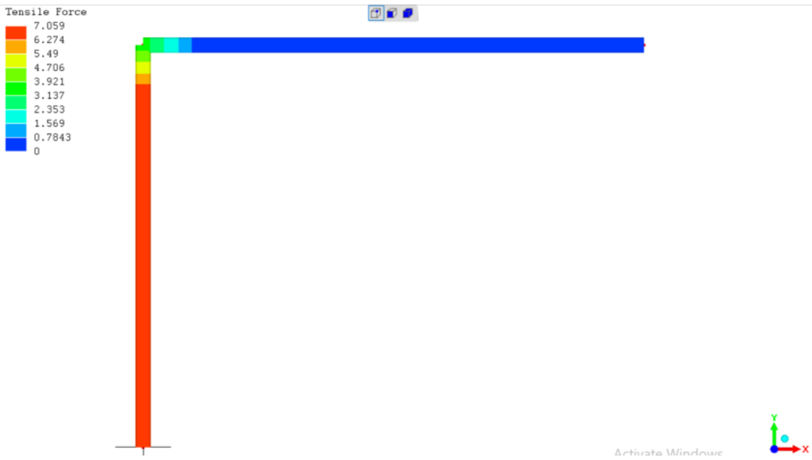

Figure 9 Tensile forces for the indetermined static frame.

Figure 10 Shear forces for the indetermined static frame.

Figure 11 Bending moments for the indetermined static frame.

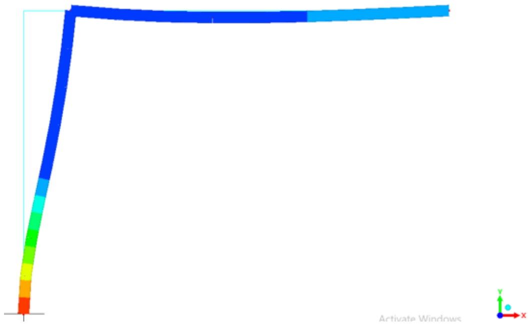

Figure 12 Deformed shape for the indetermined static frame.

CONCLUSIONS

All the static and kinematic values obtained in the study carried out by the author for the two frames were determined in the same sections from a dimensional and geometric point of view. Following the obtained data, the following conclusions can be drawn:

1. the displacements on the X and Y axes of the considered global coordinate system show, in the case of the statically determined structure, much higher values than in the case of the statically undetermined structure, with a percentage deviation of 86.3% for the maximum displacement on the X axis and a percentage deviation of 82.7% on the Y axis.

2. Regarding the sectional efforts, the percentage deviations are the following:

- for the maximum value of the axial force, the deviation is 83.4%;
- for the minimum value of the cutting force, the percentage deviation is 83.7%;
- the maximum value of the recorded cutting force is the same both for the determined static frame and for the undetermined static frame.
- the minimum value of the bending moment for both frames is the same being zero;
- for the maximum value of the bending moment, the percentage deviation is 17.65%.

3. Following the evaluation of the obtained values, it can be concluded that for the same type of frame as the geometric and structural form, as well as for the same type of material, the practical implementation of those of the undetermined static type is more advantageous from a mechanical point of view. The values obtained for the sectional efforts and the kinematic parameters are considerably lower. Therefore, the resistance and stiffness calculation imposed in their design shows values of maximum normal and tangential stresses, as well as values of displacements much lower than the admissible ones presented depending on the chosen material.

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