COMPARATIVE MECHANICAL ANALYSIS OF DIFFERENT SPECIES OF TREES USED IN FOREST CURTAINS SHOCK

Marius Serban FETEA[1]

[1]*Technical University of Cluj-Napoca, Faculty of Building Services, 128-130 B-dul 21 Decembrie, Cluj-Napoca 400604, Romania*

RESEARCH ARTICLE

Abstract

A complex analysis of the behavior of the tree species that are planted within the forest curtains requires a scientific study elaborated and documented within several educational disciplines related to both forestry problems, meteorological problems and last but not least those related to the analysis their mechanical behavior. The present paper refers to the problem of mechanical behavior.

An exact study of the mode of behavior cannot be achieved because the factors that influence the behavior of tree species present a variety of models that can be adopted so that there can be no generalization of the adopted mechanical calculation. This should be designed with a view to a rigorous result depending on several variables, among which the author took into account the following: the location of the forest curtains, the climatological analysis, as well as two species of trees. In the present work, it is aimed to determine the mechanical behavior of these species for the same conditions of exploitation of the forest curtains, taking into account the mentioned factors. In reality, to obtain rigorous solutions. From a mechanical point of view, other factors should be taken into account, among which we mention the type of soil, the volume of the crown, etc. the species of trees taken into account in the work are the poplar and the fir.

Keywords: curtains shock, displacements, static, beams.
#Corresponding author: Marius.Fetea@insta.utcluj.ro

INTRODUCTION

The mechanical analysis referred to by the author in the current work involved two stages of determining the solutions. Namely, a first stage of presentation of the calculation algorithm, followed by a numerical analysis of the rigor of the results using a numerical calculation program. The first part includes the presentation of the physical-mechanical properties of the considered tree species. Also, an important problem that was taken into account is related to the location of the forest curtain, namely in areas subject to desertification, such as the Caransebes area. From STAS, the reference value of the wind speed was considered to be the characteristic wind speed averaged over a period of 10 minutes, and determined at a height of 10 [m].
The direction of wind action was considered to be horizontal. The location of the trees was considered to be on a horizontal surface.
The proposed static, dynamic and modal mechanical analysis assumes a modeling of the shaft in the form of a variable cylindrical cross-section body. To perform a covering calculation from the point of view of precision, consider a constant section. To simplify the calculations without disturbing the accuracy of the results, it was considered that the volume of the crown for both considered species is 10% greater than the volume of the cylinder at the base of the crown.
From a mechanical point of view, the loads are given by the load from the wind in a direction perpendicular to the axis of the shaft, which will determine the bending stress of the shaft. There are two possibilities for considering the load on the shaft, namely a uniformly distributed load, respectively a linearly distributed load considering zero intensity at ground level. Also, the tree can be considered to be loaded with the weight of the spindle, the crown and the root - which will be neglected in the calculations. Under the action of these weights, the tree will be subjected to the phenomenon of buckling. As a mathematical model, the cylinder was adopted for the spindle.
A more careful and precise analysis of the possible way of actuation of the shaft can also be under the action of the vibration phenomenon. The dynamic analysis of the adopted mathematical model would follow the determination of the functions of the proper forms of vibration and of the proper pulsations attached to them.

MATERIAL AND METHOD

Within the methods adopted by the initial author, the analytical analysis of the mechanical stress was taken into account. In the second part, a numerical calculation method was applied in order to verify the correctness of the results (Martian, 1999).

E=10000$\left[\frac{N}{mm2}\right]$ poplar modulus of elasticity;

E=11500$\left[\frac{N}{mm2}\right]$– the modulus of longitudinal elasticity of the fir;

The density of poplar and fir is

$$\rho_1 = 440\left[\frac{Kg}{m^3}\right]$$

$$\rho_2 = 480\left[\frac{Kg}{m^3}\right]$$

$\sigma = 20\left[\frac{N}{mm^2}\right]$- the normal stress at the static load plop;

$\sigma = 24\left[\frac{N}{mm^2}\right]$ - the normal stress at the static stress of the fir;

$h_1 = 27\ [m]$ poplar shaft height;

$d_1 = 30\ [cm]$ the average diameter of poplar spindle;

$h_2 = 28\ [m]$ fir spindle height

$d_2 = 51\ [cm]$ the diameter of the fir tree

The pressure from wind loads will be determined using the relationship (Ille, 1983)

$$q = \frac{1}{2} \cdot \rho \cdot v_b^2\ [m]$$

The average air density was considered to be

$$\rho = 1.25\frac{Kg}{m^3}$$

q - dynamic wind pressure expressed in N/mm2

ρ - air density;

v_b - the reference value of the wind speed according to regulations.

$$v_b = \sqrt{\frac{2 \cdot q}{\rho}} = \sqrt{1.6 \cdot q}\left[\left[\frac{m}{s^2}\right]\right.$$

$$q\left[\frac{N}{mm^2}\right] = 0.625 \cdot v_b^2\left[\frac{m}{s^2}\right]$$

According to the zoning map of the territory of Romania for the Caransebes area treated in the work by the author, the pressure from wind loads is

$$q = 0.6\left[\frac{KN}{m^2}\right]$$

The mathematical model adopted regarding the geometric shape of the poplar is a cylinder and for the fir the cone (Ille, Bia, Soare, 1983)

The volume of the cylindrical spindle in poplar and the spindle in fir is determined with the relations:

$$V_1 = \frac{\pi}{4} d1^2 \cdot h1[m^3]$$

$$V_2 = \frac{\pi}{8} {d_2}^2 \cdot h_2[m^3]$$

The diameters and heights of the poplar and fir crowns are

$$d_{C1} = 1.5 \cdot d_1$$

$$d_{C2} = d_2 \cdot \sqrt{3}\ [cm]$$

$$h_{C1} = 0.7 \cdot h_1\ [m]$$

$$h_{C2} = 0.1 \cdot h_2\ [m]$$

The total weight taken into account consists of the weight of the spindle and the crown. It is considered to act as a uniformly distributed load in the case of poplar and as a linear distributed load in the case of fir, having the maximum intensity at the base of the spindle (Bors, 2005).

$$G_{tot2} = G_{C2} + G_2[N]$$

$$G_2 = \gamma_2 \cdot \frac{\pi}{4} {d_2}^2$$

$$G_{C2} = \gamma_2 \cdot \frac{\pi}{20} {d_2}^2 \cdot h_2$$

$$G_{tot1} = G_{C1} + G_1[N]$$

$$G_1 = \gamma \cdot \frac{\pi}{4} {d_1}^2$$

$$G_{C1} = \gamma_1 \cdot \frac{\pi}{4} {d_{C1}}^2$$

$$\gamma_1 = 550\left[\frac{Kg}{m^3}\right]$$

$$\gamma_2 = 480\left[\frac{Kg}{m^3}\right]$$

The application points of the gravity forces and were determined using the relationship for determining the coordinates of the centers of gravity along the axis (Barsan, 2003)

$$x_{G1} = \frac{G_1 \cdot x_1 + G_{C1} \cdot x_{C1}}{G_{TOT1}}$$

$$x_{C1} = \frac{h_{C1}}{2}$$

$$x_{G2} = \frac{G_2 \cdot x_2 + G_{C2} \cdot x_{C2}}{G_{TOT2}}$$

$$x_{C2} = \frac{2 \cdot h_1}{30}$$

RESULTS AND DISCUSSIONS

The analysis was carried out in 2 stages. In a first stage, the geometric dimensional values of the two species of trees were analytically determined.

The vertical action of the wind load on the axis was taken into account

Case 1 – poplar

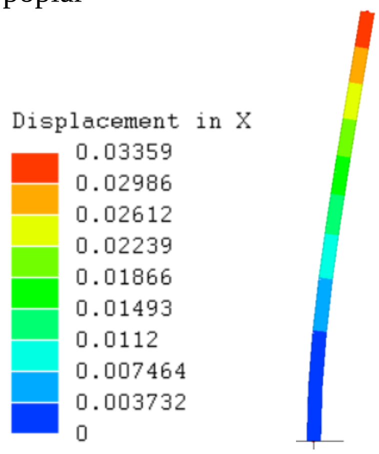


Fig.1 **Spindle deformation - poplar**

Using the analitycal and numerical calculation program Lisa (Ghinea 2004), the 2 beams were modeled in a 2D graphic representation, namely the wooden beam whose graphic representations of the values of displacements X coordinate axis are represented in figures 1 to 17

Dynamic analysis of displacements on the X axis of the poplar canopy. For t= 0-2.5 [sec].

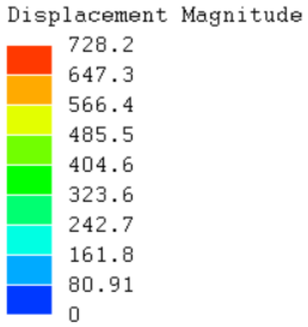


Fig.2 **Deplasarile coronamentului - plop**

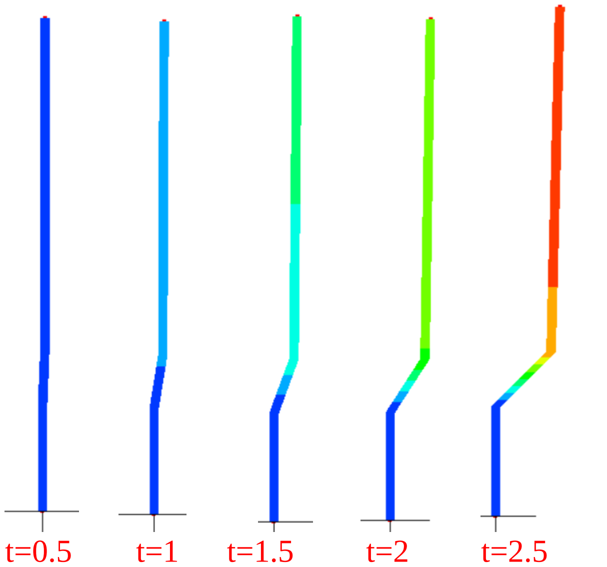


Fig.3 **The deformations of the crown - poplar**

Dynamic analysis of movements on the X-axis of the poplar spindle. For t=0 –2.5 [sec].

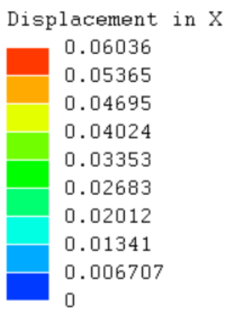


Fig.4 **Spindle movements - poplar**

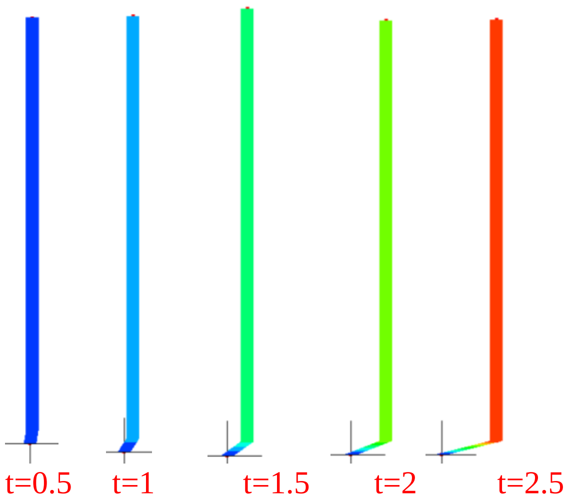


Fig.5 **Spindle deformations - poplar**

Modal analysis of the poplar spindle corresponding to the first three normal modes of vibration. The spindle displacements on the first normal mode of vibration are:
f1=7.810041

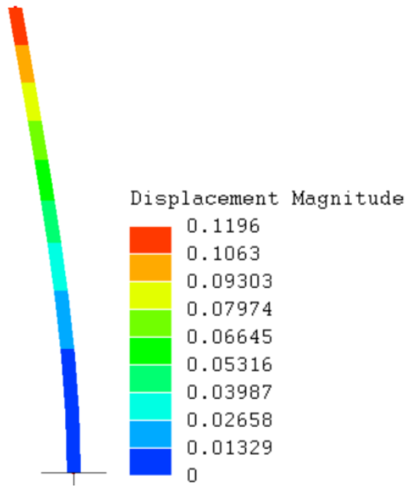


Fig.6. **Deformed and displacements of the spindle - poplar**

The spindle displacements for the second normal mode of vibration are
f2=48.94851

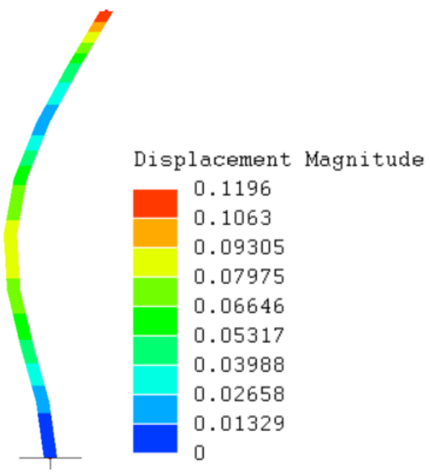


Fig.7 **Deformed and displacements of the spindle - poplar**

The spindle displacements for the third normal mode of vibration are
f3=137.1296

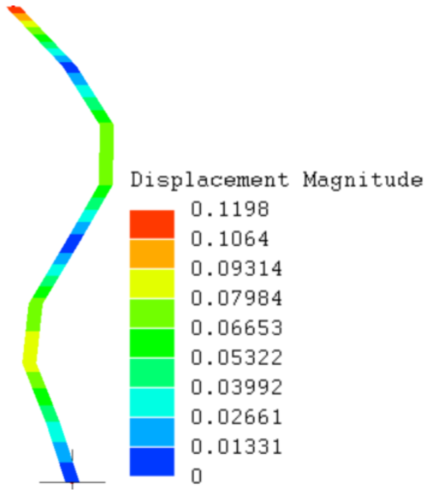


Fig.8 **Deformed and displacements of the spindle - poplar**

Modal analysis of the poplar canopy corresponding to the first three normal modes of vibration. The displacements of the crown on the first normal mode of vibration
e f1=13.45635.

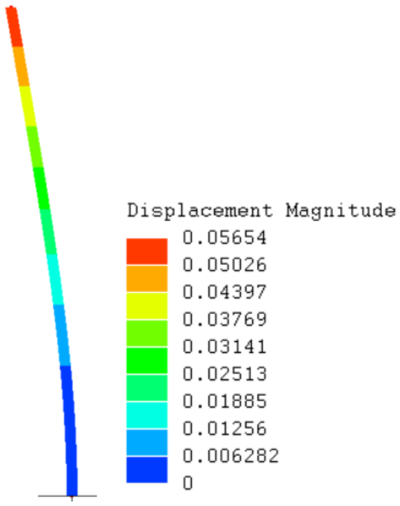


Fig.9**. Deformation and displacements of the canopy - poplar**

The crown displacements for the second normal mode of vibration are
f2=84.32993

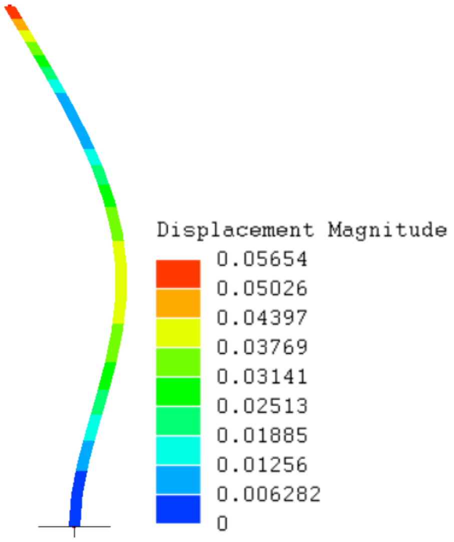


Fig.10 **Deformation and displacements of the canopy - poplar**

The crown displacements for the third normal mode of vibration are
f3=209.467

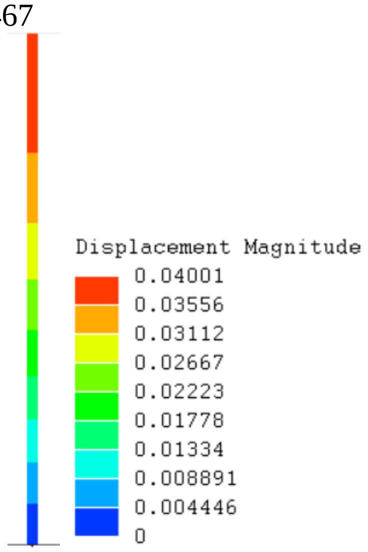


Fig.11. **Deformation and displacements of the canopy - poplar**

Analysis of the behavior of the static wind loads of the fir spindle.

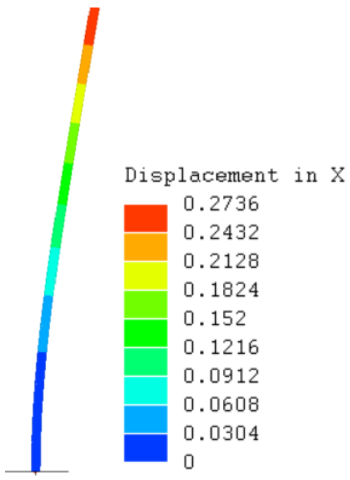


Fig.12 **Deformed and displacements of the spindle - fir**

Analysis of the behavior of the fir canopy under static wind loads

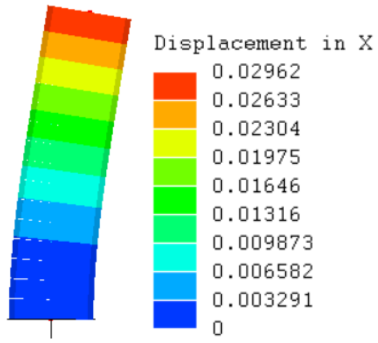


Fig.13 **Deformed and displacements of the crown - fir tree**

Analysis of the dynamic load behavior of the fir spindl.

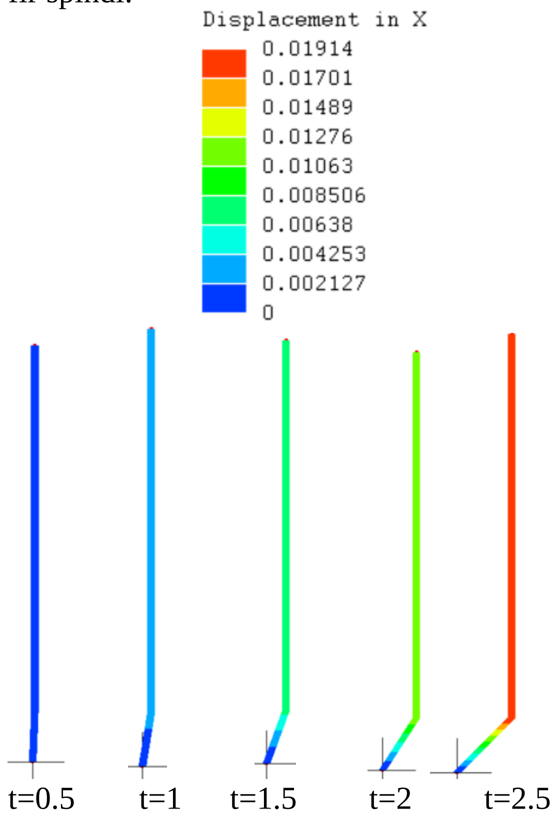
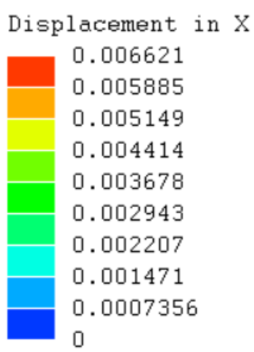


Fig.14 **Deformed and displacements of the spindle - fir**

Dynamic analysis of the displacements on the X axis of the fir crown. For t=0–2.5 [sec].



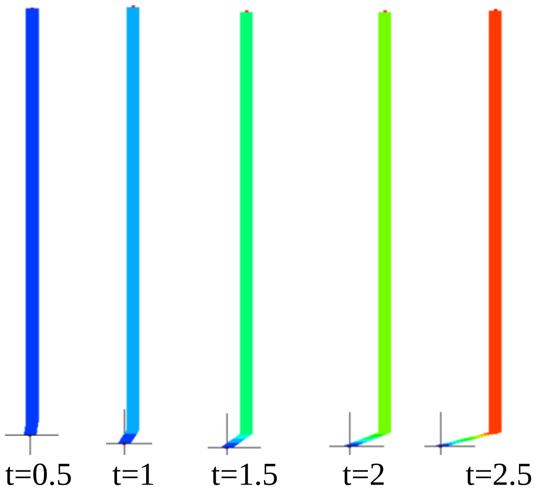


Fig. 15 **Deformata si deplasarile fusului – Abies sp.**

Modal analysis of the poplar spindle corresponding to the first three normal modes of vibration. The spindle displacements on the first normal mode of vibration are for f1=1.461

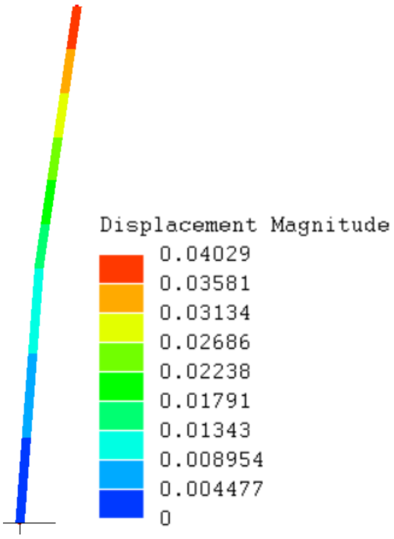


Fig.16 **Deformed and displacements of the crown - fir tree**

The spindle displacements for the second normal mode of vibration are for f2=9.230

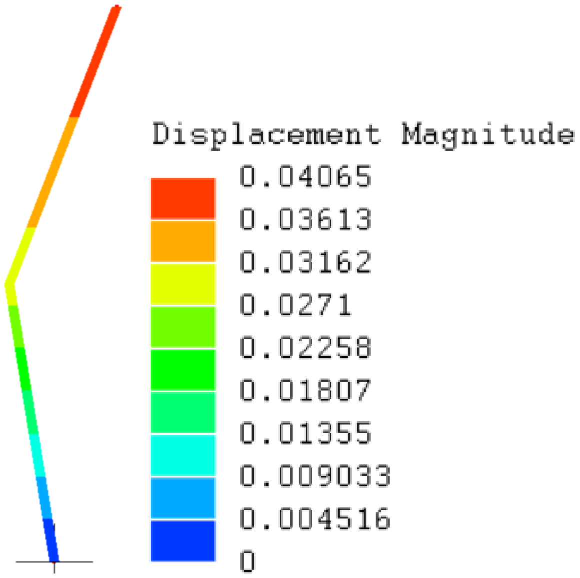


Fig.17. **Deformed and displacements of the spindle - fir**

Table 1

The displacements along the X axes for dynamic analysis – Populus L.
The kinematic parameters of the spindle of poplar and

For the spindle of poplar and fir	Time step 0 Time 0	Time step 1 Time 0.5	Time step 2 Time 1	Time step 3 Time 1.5	Time step 4 Time 2	Time step 5 Time 2.5
Displacements	0	0.013	0.020	0.033	0.040	0.060
Displacements	0	0.002	0.004	0.008	0.012	0.019

Table 2

The kinematic parameters of the poplar and fir crown

For the spindle of poplar and fir	Time step 0 Time 0	Time step 1 Time 0.5	Time step 2 Time 1	Time step 3 Time 1.5	Time step 4 Time 2	Time step 4 Time 2.5
Displacements	0	0.161	0.323	0.404	0.6	0.72
Displacements	0	0.141	0.029	0.044	0.0051	0.0066

Table 3

Vibrational analysis of the wooden structure recorded the poplar and fir crown

Modes	Mode 1	Mode 2	Mode 3
Displacements	0.1196	0.1196	0.1198
Displacements	1.1835	4.4833	7.4763

Table 4

The vibrational analysis of the wooden structure recorded the poplar and fir spindle

Modes	Mode 1	Mode 2	Mode 3
Displacements	0.058	0.056	0.040
Displacements	1.461	9.233	31.217

CONCLUSIONS

From the multitude of data presented by the author in this paper, the following main conclusions can be drawn:

1. From the dynamic analysis of the two species of trees, it is found that the poplar shows greater elasticity, which is why it is less resistant;
2. The maximum movement on the crown and on the spindle in the case of the poplar is 0.06[m], respectively 0.72[m].
3. The dynamic analysis of the fir shows a much improved situation from a mechanical point of view compared to the poplar, having displacements of 0.0066 [m] on the crown and on the spindle. and 0.019[m];
4. The percentage deviation for the poplar spindle being 68.33% higher than for the fir;
5. The percentage deviation for the crown of the poplar is 99% compared to the fir.
6. Regarding needles, the pulsations for the first three normal modes of vibration are much higher in the case of the fir both on the spindle and on the crown.
7. In the case of the static application of the load from the wind, the maximum displacement of the poplar is approximately 20% greater than in the case of the fir.

As a conclusion that can be drawn from the mechanical analysis of the two species of trees, poplar has weaker mechanical and kinematic characteristics than fir. Therefore, in the same conditions of wind loads, it is safer to use fir road curtains.

REFERENCES

Bârsan, G: 2003 Dinamics and stability of structures (Dinamica şi stabilitatea construcţiilor), Editura Didactică şi Pedagogică Bucureşti, 1979.

Bors I, 2005 MECANICA, Compendiu teoretic si aplicatii de cinematica, dinamica si mecanica analitica, UTpres, Cluj-Napoca

Ille V 1977, Rezistenta Materialelor, Editura LITO Politehnica Cluj Napoca.

Ille V, Bia C, Soare M., 1983, Rezistenta Materialelor si Teoria Elasticitatii, Editura Didactica si Pedagogica, Bucuresti.
Ghinea M., Fireteanu V., 2004 Matlab, Calcul numeric, grafica, aplicatii. Editura Teora. Bucuresti.
Martian I.:1999 Theory of Plasticity and Elasticity (Teoria Elasticitatii si Plasticitati)i. LITO UTCN..
Soare, M. 1999 Differential equations with applications in mechanical construction (Ecuaţii diferenţiale cu aplicaţii în mecanica construcţiilor), Editura Tehnică, Bucureşti.