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# DESIGN OF DIGITAL ANALYSIS PROGRAMS FOR THREE TYPES OF WOODEN STRUCTURES DIFFERENT AS EXTERNAL LOADING USING THE INITIAL PARAMETERS METHOD

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***Abstract***

*In the present paper, the author presents the numerical analysis of the deformations from the main sections of the wooden structures by the method of the initial parameters. This work was carried out out of the desire to present a simpler numerical calculation algorithm than the classic case of analytical solving of these types of problems. Also, the use of numerical calculation allowed the reduction of the long time necessary to determine rigorous solutions compared to known analytical methods. In the paper presented by the author, the solution of the problems was done by applying the Matlab numerical calculation program..*

**Key words:** numerical derivate, beam, wood, deflections.

## INTRODUCTION

In the present paper, the author started the study from a structure of the type of recessed wooden beams that were loaded separately with three types of forces and external moments. Each case was treated in a separate paper. The beam was considered to have the same dimensional values in terms of its length and cross section. The length is three meters, and the section is circular with the same diameter D. Young's module was considered to have the same value $E = 0.12 \cdot 10^5\ [N/mm^2]$. For all cases the stiffness of the bending beam is considered to be the constant E · I = const.

The first structure studied was the case of a claped and loaded beam with a force evenly distributed along its entire length having the intensity q = 20 [N/m].

The second structure studied was the recessed bar loaded with a force concentrated at a distance of 1 [m] from the clamped end. The modulus of the concentrated force was considered to be F = 6 [KN].

The third structure studied was the recessed bar loaded with two concentrated outer moments, namely a moment M1 = 3 [KNm] and an outer moment M2 = 5 [KNm]. The outer moment M1, acts at a distance of 1 [m] from the embedded end, and the moment M2 at a distance of 2 [m] from the same end.

The calculation was initially done analytically for all three cases, after which it was performed numerically by the author designing three calculation programs in Matlab. Within the analytical calculation, the determined expressions of the mechanical displacement were presented, followed by successive derivations in relation to the independent parameter “x” of the mechanical rotation, of the bending moment and of the shear force (Marţian,1999, Fetea, 2010).

The studied wooden bar has the following characteristics:

- the length of the bar is 3.0 [m];
- the beam section is circular with initially unknown diameter D=250[mm];
- the beam is considered to be embedded in the structure of a roof of a family home;
- the longitudinal modulus of elasticity for humidity of 12% is $E = 0.12 \cdot 10^5\ [N/mm^2]$.
- the moment of axial inertia of the section, I = (π · D^4)/64 [m^4];
- the allowable arrow was considered to be, L/1000 = 3 [mm]
- allowable rotation, φ_adm = 1°
- uniformly distributed load having intensity q = 20 [N/m].

## MATERIAL AND METHOD

The analytical study of the considered bar presents the following calculation algorithm:

- the connecting forces and moment bending in the supports were determined;

- based on the known general equation of the initial parameters, taking into account for each case, the original parameters were highlighted, represented by the shear force $V_A = T_A$ and the bending moment $M_A$of clamped edge. The initial parameters are the same in all three cases studied, only their values differ;

- using the derivation method, the expressions of rotation, bending moment and shear force were analytically determined. (Ciofoaia, 2001), (Ivan,1997);

- considering the free end of the beam, in this section the maximum values of the mechanical displacement and of the mechanical rotation will be registered, respectively the minimum values of the bending moment and of the shear force.

- in the second part of the paper, the author presents the calculation programs designed for the three structures studied, using Matlab program.

$$\sum M_A = 0$$
$$-V_B L + q\frac{L^2}{2} = 0$$
$$V_B = q\frac{L}{2}$$
$$V_B = V_A = 20[KN]$$

The analysis follows the classic stages of mechanical calculation of the bars, determining according to the calculation algorithm the following parameters:

The efforts in the main sections beam (Catarig., 2001), (Missir, 2002):

$$M_B = M_A = 0[KNm]$$
$$M_C = 10[KNm]$$

The shear forces in A and B sections

$$T_A = V_A = 20[KN]$$
$$T_B = V_B = -20[KN]$$

The dimensioning of the dangerous section will be done using the resistance condition in normal mechanical stresses (Catarig., 2001), (Ille V., 1981)

$$\sigma_{max} = \frac{M_{max}}{W_{nec}} \leq \sigma_{adm}$$
$$\downarrow$$
$$D_{nec} = 189.7[mm]$$
$$D_{ef} = D_{nec} + 5 = 194.7[mm]$$

Checking the dangerous section of the beam in normal mechanical stresses leads to the result (Missir V., 2002):

$$\sigma_{max} = \frac{M_{max}}{W_{ef}} = 13.87[\frac{N}{mm^2}] \leq \sigma_{adm}$$

To determine the expressions of rotation and displacement along the axis of the bar, the method of direct integration of the differential equation of the deformed axis of the bar was used (Hadar, 1998). Starting from the expression of the bending moment along the beam axis, written according to the independent parameter "x", by two successive integrations the expressions of rotation and displacements were determined. The expressions do not allow their direct determination being a function of two integration constants (Catarig., 2001) , (Goia, 2000). By imposing the conditions at the limits, the two integration constants C2 = 0 and C1 = 6.66 were determined

$$\varphi = \frac{dv}{dx} = -\frac{1}{EI}\int \left(V_A x - q\frac{x^2}{2}\right) dx + C_1$$

$$v = \frac{d\varphi}{dx} = -\frac{1}{EI}\int (V_A \frac{x^2}{2} - q\frac{x^3}{6} dx + C_1) dx + C_2$$

Imposing for x=0 [m] and x=2 [m] result:

$$C_1 = 6.66$$

$$C_2 = 0$$

**RESULTS AND DISCUSSION**

For the case studied. a numerical calculation program was designed in Matlab, aiming to determine the same parameters as in the case of the analytical study of the beam (Muntenu Gh.,1998). The following calculation program designed by the author and named - deflectionbeamssolve -MSF was made.

```
% Name program – "Deflectionbeamssolve – MSF"
% Effort study

% L – beam length [m]

% q - uniformly distributed load intensity [KN/m^2]

% VA, VB - forces
% R, mechanical resulting force of uniformly distributed force

% Vadm, allowable displacement[mm]

Sigmaadm=15

L =0:.2:2
Vadm=(L(1,11)*10^3)./1000
q=20
% Determination of sectional efforts

% Shear forces - TA, TB

R=20*L(1,11)
VA=R./2
VB=VA
TA=VA
TB=-VB
```

```
 syms T(x)
T(x) = VA-q*x
sol = vpasolve(T)
for x=L(1,6)
   T(x)
end
 TC=T(x)
T=[TA TC TB]
 % Bending moments
% MA, MB, MC –bending moments
MA=0
MB=0
syms M(x)
M(x)=VA*x-(q*x^2)/2
solMx = vpasolve(M)

for x=L(1,6)
   M(x)
end
MC=M(x)
 % Analysis of the mechanical strength condition

Sigmaadm=15
 syms x
 g(x)=x-((32*MC*10^6)/(pi*Sigmaadm))^(1/3)
 solgx=vpasolve(g)
Dnec=solgx
Def=Dnec+5
M=[MA MC MB]
% Mechanical determination of the diameter of the dangerous section.

Sigmaadm=15

% " Sigmaadm" Admissible mechanical stress in [N/mm^2]
% Def - the effective diameter of the dangerous section

% Verification of dangerous section

% W - the effective mechanical resistance module of dangerous section
Wef = (pi*Def^3)/32
Sigmamax = (MC*(10^6))/Wef
% Check the mechanical stress allowed by15 [N/mm^2]

% Beam stiffness calculation
```

```
% E – Young's modulus [daN/cm^2]
% I - moment of axial inertia [mm^4]

E=0.1*10^5
I=(pi*Def^4)/64
syms rot(x)
ode=diff(rot,x) == -(VA*x-(q*x^2)/2)
rotSol(x) = dsolve(ode)
x=0:.2:2
rot=6.66 + (10*x.^2.*(x - 3))./3
plot(x,rot)
 % Mechanical check of rotation in the middle of the beam opening= 0
for x=1
   rotSol(x)
end
C1=6.66
 % Determining the equation of displacement by integrating the first
derivative of the rotation, respectively the second derivative of the bending
moment.
syms v(x)

ode=diff(v,x) == C1 + (10*x^2*(x - 3))/3
vSol(x) = dsolve(ode)
 x=0:.2:2
v=((5*x.^4)/6 - (10*x.^3)/3 + x.*C1 + C2)
plot(x,v)

 for x=2
    for C1=6.66
       vSol(x)
    end
 end
C2=0
 % Determining the displacement equation by integrating the second order
differential equation of the deformed axis and imposing boundary
conditions on the ends of the bar for x = 0 and x = 2
syms v(x)
Dv = diff(v);
ode = diff(v,x,2) == -(VA*x-(q*x^2)/2)
cond1 = v(0) == 0;
cond2 = v(2) == 0;
conds = [cond1 cond2];
```

```
vSol(x) = dsolve(ode,conds)
vSol = simplify(vSol)
for C1=6.66
   for C2=0
      vSol(x)
   end
end
for x=1000
   (vSol(x)/(E*I))
end
% Mechanical determination of maximum rotation
rotation= C1 + (10*x^2*(x - 3))/3
for x=2000
    rotation/(E*I)
end
f1=rotation/(E*I)
% maximum rotation in degrees
maximumrotation=f1*360/(2*pi)
% Check the maximum rotation being 1 degree!
```

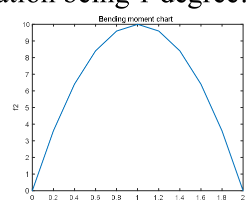


Fig. 1.Bending moment chart

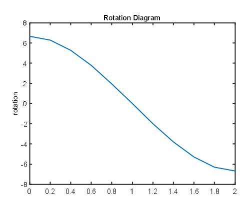


Fig. 2. Rotation diagram along the x-axis

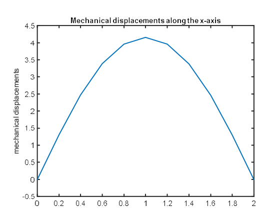


Fig. 3 Mechanical displacements along the x-axis

## CONCLUSIONS

The conclusions that can be drawn from this comparative study are the following:

1. The elaboration of this program by the author represents an element of novelty, which allows solving any problem of static calculation of wooden beams, regardless of the external forces acting, the type of wood material, its mechanical-physical characteristics. The problem is easy to solve just by changing the values in the program. This feature will make the work of any engineer easier, being necessary to apply only the calculation program used.
2. As a conlusion, the „smart program" use to solve the deflections beams problem can be use in the light wood construction fields because will reduce significantly the time necessary to determine the correct values for the dimensioning of the section, its verification, the determination of the maximum displacements and rotations or in any section of the bar.
3. The practical implementation of numerical calculation methods is certainly in the future the only viable methods in quickly and accurately solving computational problems in engineering.

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