STUDY REGARDING THE STATIC AND DYNAMIC ANALYSIS OF WOOD BEAMS LOADING BY UNIFORM AND CONCENTRATED FORCES

Fetea Marius*, Mare Roxana*

*Technical University of Cluj-Napoca, Faculty of Building Services, 128-130, 21 Decembrie 1989 Bld., 400604 Cluj-Napoca, Romania, e-mail: marius_fetea@yahoo.com roxana.mare@insta.utcluj.ro,

Abstract

The main aim of this study is to determine the values of maximum sectional tensions and displacements from the principal sections of wooden beams under the static and dynamic loadings. Also, a major importance will is given in the determination of the percentage differences that occur between mechanical characteristic values determined from static and dynamic loads.

Key words: (maximum 6): *beam, dynamic, static, wood, design*

INTRODUCTION

It is known that during the application of forces on the elements of wood construction, it passes low speed from undeformed position in the deformed position, so that under the influence of static loads the wooden elements are found at rest. Introducing the inertial forces by D'Alembert principle, the strucutural element of wood construction will have to be in equilibrium under the action of external forces and inertial forces.

To determine the state of stresses and strains in the transversal sections of wooden beams, is admitted the hypothesis that equilibrium is realized on undeformed shapes of the beams. The problem starts resolving by a analogy with a static load.

The main aim of this study is to determine the values of maximum sectional tensions and displacements from the principal sections of wooden beams under the static and dynamic loadings (Bia et al, 1983). Also a major importance will be given to determining the percentage differences that occur between mechanical characteristic values determined from static and dynamic loads (Ille 1977).

MATERIAL AND METHOD

Analytical and numerical methods are used to determine the stress and the displacements (Fetea M. 2010). For a rigorous comparison to static and dynamic performance study considered the same type of element, namely a beam of wood with the following dimensions:

- length of the beam $L = 3000[mm]$

- beam width $l = 200[mm]$
- beam height $h = 200[mm]$

The beam is made of pine wood with 15% moisture and density

$$\rho = 0.55\left[\frac{Kg}{dm^3}\right].$$

Given the general mode of action of its own weight and external forces that currently manifests on these types of structures, in this paper is considered their uniform actions.

In both cases, the study considered the horizontal position of the beam, being supported at the ends by a simple support and a hinged support. Static and dynamic study of the beam will be made considering the appropriate median plane surface XY.

For the case of static beam calculation, the external forces corresponding to the loads of others elements of the building and are taken by the beam and forward to the resistance structure. There are considered as having a uniformly distributed action that occurs on the surface of the beam with the intensity

$$q = 1000\left[\frac{daN}{cm^2}\right]$$

Regarding the weight of the beam it will be determined using the relation:

$$G = m \cdot g$$
$$\downarrow$$
$$G = \rho \cdot V \cdot g$$
$$\downarrow$$
$$G = \rho \cdot L \cdot l \cdot h \cdot g$$

Where:

m, beam mass;

V, total volume of the beam;

g, gravitational acceleration.

The value of its own weight of beam is:

$$G \approx 432[N] = 43{,}2[daN]$$

Total force that will operate uniformly distributed over the beam is:

$$F = G + q \cdot L = 3043{,}2[dan]$$

The maximum static displacement along the Y axis will be determined analytically using the relation (Ivan, 1997):

$$\Delta_{ST} = \frac{F \cdot L}{48EI}$$

Where: E, Young's modulus;

I, axial moment of inertia about the X and Y axis.

$$E = 0{,}1 \cdot 10^6 \left[\frac{daN}{cm^2} \right]$$

$$I_X = I_Y = \frac{h \cdot l^3}{12} = 13333{,}3 [cm^4]$$

For accuracy and precision is used numerical calculation with the finite element method. Finite element static calculation of structures involves the few steps (Blumenfeld 1995). Geometric structure is modeled for static analysis using a numerical program. Numerical method used is the finite element method.

Numerical modeling of the structure is presented in Figure 1 to 9.

Numerical modeling involves:

- entering the coordinates basic element;
- shaping the basic element;
-physico-mechanical properties attachment and cross-sectional geometry selection;
- dividing the principal element in the finite element;
- constraints attaching to the meshed structure;
- loading the structure with resultant forces.

Element nodes are created mainly with plane coordinates given by its length and height (Fig. 1).

Fig. 1 The principal nodes.

We create the principal element using the 4 nodes (Fig. 2).

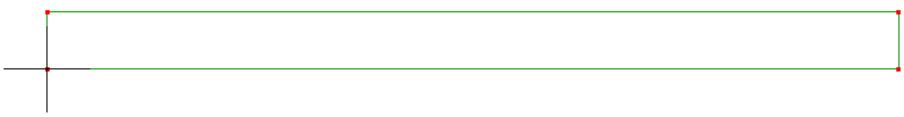

Fig. 2 The principal element.

The beam finite elements are created (Fig. 3).

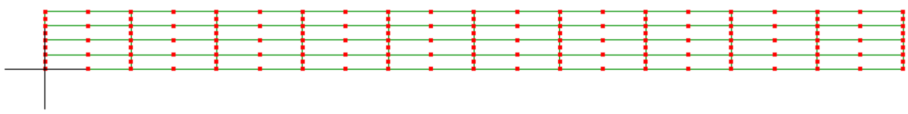

Fig. 3 The finite elements of the wood beam.

It is applied the corresponding constraints (Fig. 4)

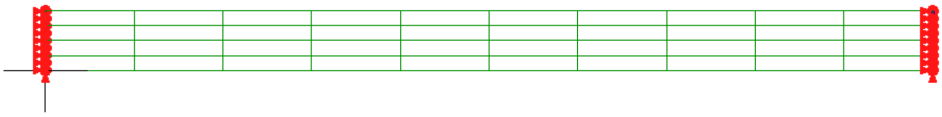

Fig. 4 Applying constraints at the ends of the beam.

Total static load is applied $F = 3043.2[dan] \approx 30432[N]$ (Fig. 5).

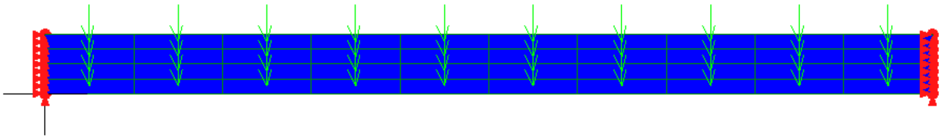

Fig. 5 Static load.

The cross section displacement points by axis Y (Fig. 6).

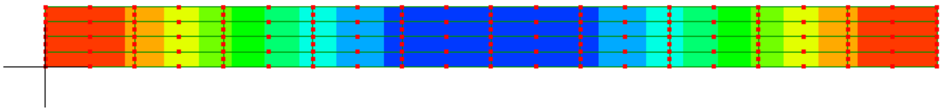

Fig. 6 Displacements by Y axis.

The deformed beam and the general picture of displacement along the Y axis (Fig. 7)

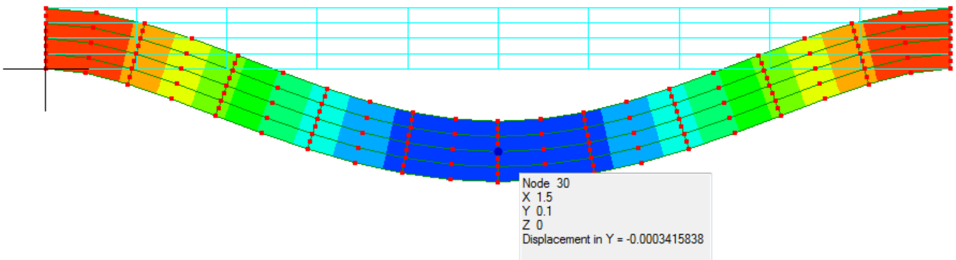

Fig. 7 The deformed beam and general displacements.

Normal stresses and their distribution along the Y axis (Fig. 8)

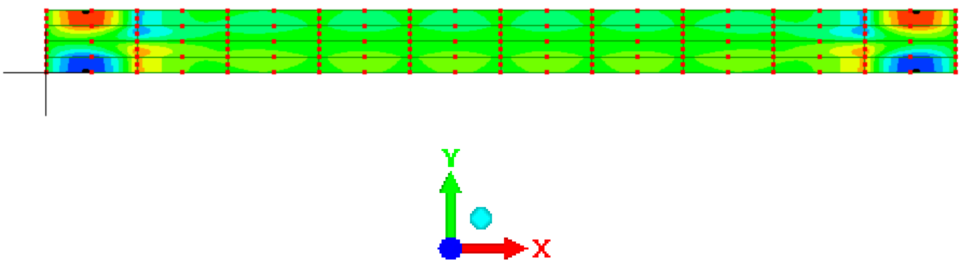

Fig. 8 Stresses distribution by Y axis.

The deformed beam and the general picture of stress points along the Y axis.

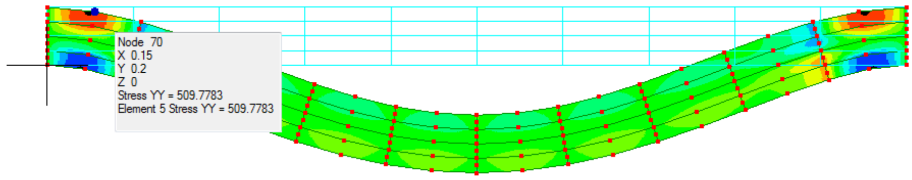

Fig. 9 Deformed beam obtained by stress analysis by Y axis.

There are many situations when the values forces are changing during their application. Under this actions the beam will be in motion (Munteanu, 1998), so in this situation the accelerations of different points of the beam will not be negligible, the application process being characterized by the appearance of inertial forces (Ivan, 1997).

Dynamic load is given by the fall of a body on the beam, taking place in this case a dynamic application by shock the acceleration rapidly varying in time. It was considered that the beam is requested dynamically by shock at its midspan with a force $P_S = 2000[daN]$, falls from a height $H = 10[cm]$.

Were considered the following coefficients (Ille, 1977).

k_1, coefficient of mass reduction for the quantity of movement;

k_2, the mass coefficient for reducing quantity of kinetic energy;

Values are known (Ille, 1977):

$$k_1 = \frac{5}{8}$$

$$k_2 = \frac{17}{35}$$

We adopt the notation Ψ for the dynamic coefficient. Dynamic coefficient is determined using the relation (Catarig et al, 2001):

$$\Psi = 1 + \sqrt{1 + \frac{2H}{\Delta_{ST}} \frac{1 + k_2 \cdot \frac{F}{P_S}}{\left(1 + k_1 \cdot \frac{F}{P_S}\right)^2}} = 69,6$$

Normal dynamic tension along the Y axis is determined using the relation (Ille 1977):

$$\sigma_{Yd\max} = \sigma_{yst\max} \cdot \Psi$$

Maximum displacement along the Y axis is determined analytically using the relation (Ille, 1977):

$$\Delta_D = \Delta_{ST} \cdot \Psi$$

Following the same numerical algorithm by finite element method is determined the dynamic displacements, the nodal normal stresses and maximum displacement along the axis Y (Sandu and Sandu, 2003).

RESULTS AND DISSCUSIONS

By applying analytical and numerical methods of calculation are obtained the stress values and displacements in the sections of the considered beam. Following the numerical method we obtained the following values of the static displacements of cross-section by Y-axis (Botis, 2005). Displacements were obtained in centimeters (Fig. 10).

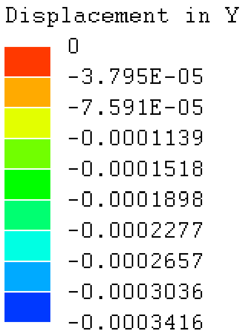

Fig. 10 Displacement values by Y axis.

By applying the numerical method we obtained the following values of the static normal stress along Y axis (Botis, 2005). Normal stresses along the Y axis were obtained in $\left[\frac{daN}{cm^2}\right]$ (Fig. 11).

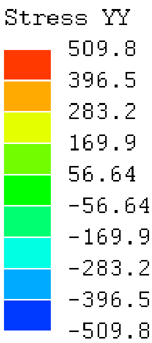

Fig. 11 Stress values by Y axis

The maximum displacement in dynamic regime occurs in the middle of the beam and has the value:

$$\Delta_D = 0,023[cm] = 0.23[mm]$$

Maximum dynamics stress is determined using the relation (Ille, 1977).

$$\sigma_{Yd\max} = \sigma_{yst\max} \cdot \Psi \ .$$

Considering the maximum normal static stress that are registered in node 70 of the beam and having the value

$$\sigma_{yst\max} = 5{,}098\left[\frac{daN}{mm^2}\right],$$

is obtained the maximum dynamic stress (Ille 1977):

$$\sigma_{Yd\max} = 351{,}76\left[\frac{daN}{mm^2}\right]$$

The results determined on the beam of wooden material, can be considered as a example for future calculations.

CONCLUSIONS

The results obtained from calculations have a particular importance, being able to draw the following conclusions:

- regarding the static displacements they represent 1.47% of the dynamic displacements, so that should be given importance to the dynamic solicitations of wood beams.
- the maximum values of displacements are registered in the middle beam cross sections
- regarding the maximum normal stress by the Y axis for the beams loaded static, it represents 1.44% of the maximum dynamic stress.
- the calculation of wood structural elements of the building must focus intensely for the dynamic loads that occur in phenomenon.
- the calculation to determine the efforts will be made necessarily for the case of dynamic beam solicitation.

The comparative study presented in this paper demonstrates the usefulness of the results obtained by analyzing the constructive elements of the beam in terms of both dynamic and static, to be able to avoid the dangerous phenomena

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