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Determining the Calculated Length of Wooden Columns, Taking Into Account the Elastic Pliability of the Support Nodes

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Abstract— *The combination of wooden pillars with the foundation is the most responsible part of the knot. The strength of the glued wooden column, which is attached to the foundation with metal elements, depends on the state of strength-deformation in the influence of the longitudinal load and bending moment of the elements used in the combination. The article presents theoretical information on determining the strength and deformation of the base node attached to the foundation by metal elements.*

Keywords— *Wooden glued column, responsible node, metal elements, Stepsons, basic assumptions, displacement, deflection, bending of overlays, stiffness, cross-sectional area.*

I. Introduction

The main directions of economic and social development of Uzbekistan include increasing the level of industrialization and the degree of factory readiness of various industries and construction structures [1]. In this regard, in recent years, a broad problem of organizing factory production of lightweight, including wooden glued structures has been successfully implemented [2, 3].

The use of wooden frames with posts that are rigidly connected to the foundations, in some cases, is more appropriate in comparison with frames that have rigid eaves, frames of the strut type, etc. For example, most agricultural buildings have a small height, so that the bending moments from the wind load in the pinched columns in the rack-and-beam frames of such buildings are sometimes ten times smaller than the frame nodes of commonly used three-frame frames. This creates great structural convenience and opportunities to simplify the structural form of frames, which the designer can use [2].

In industrial buildings, the use of a frame with columns firmly pinched in the foundations is a traditional solution that essentially has no alternative.

In the practice of agricultural construction abroad, the pinching of wooden posts in the rack-and-beam frames of light buildings is carried out by locking the ends of the posts in concrete foundations [5, 6].

This solution of support units is possible only for temporary buildings and under the condition of deep impregnation of racks with water-resistant antiseptics. The service life of such support units does not exceed, apparently, the service life of similar racks, anchored for the purpose of pinching directly into the ground. In addition, the use of this constructive technique is possible only when the action of relatively small bending moments and longitudinal compressive forces [9].

Known design hard pinching wooden racks, osushestvlyaetsya with consoles stepchildren, for example, trapped by the wooden poles overhead lines, installation of radio and transmission widely used concrete and wooden consoles – stepchildren and connections on wire twisting [2].

Foreign firms have proposed and used support units that ensure the clamping of glued columns in the foundations with the help of glued reinforcing bars, bolts, etc. (Figure 1) [7].

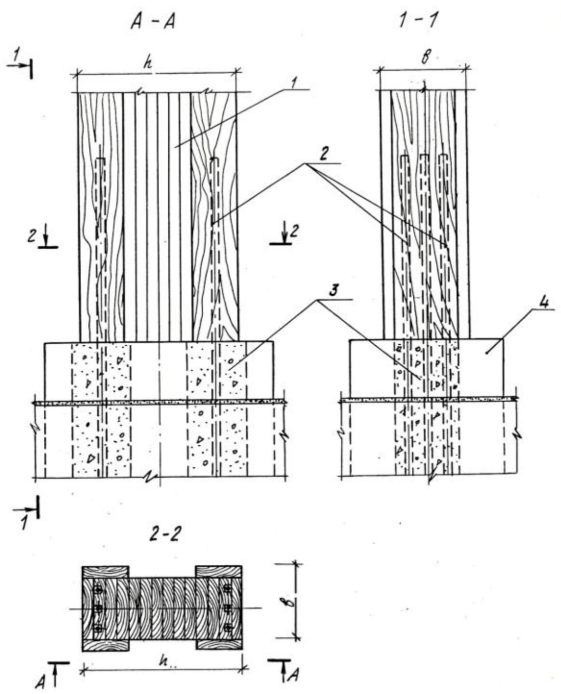

Figure 1. Support node design used by Finnish companies: 1-glued column; 2-steel rods; 3-wells; 4-Foundation.

Special attention should be paid to the design of pinching glued columns used by famous Finnish builders. In this case, the column is reinforced in its lower part with steel rods glued into the wood, released from the column body. The ends of these rods are installed in the open wells of the Foundation and sealed in them with concrete after reconciliation and

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temporary loosening of the columns in the design position. (Figure 2) [7].

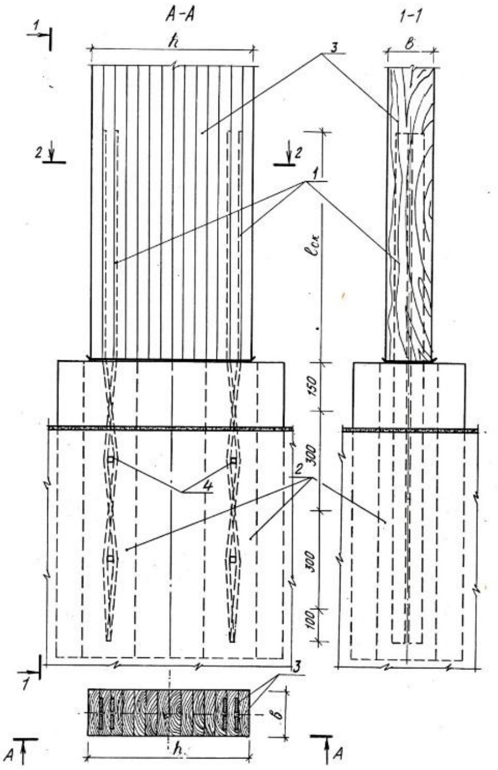

Figure 2. Construction of pinching glued wooden columns using steel bands of wires: 1-steel bands; 2-sockets; 3-column; 4-babyshki.

Such designs of support units are unacceptable when significant bending moments and vertical loads are applied in the pinches [2].

When determining the estimated length of glued columns, which are pinched in the Foundation by means of rebar connections with wood or metal Stepsons, it is necessary to determine the coefficient of length reduction μ_0.

This coefficient depends on the flexibility of the connecting elements, such as bolts, strands, linings, as well as the deformability of the connection between the reinforcement and the wood. Due to the flexibility of these elements, the reduction coefficient of the length μ_0 increases, thereby increasing the calculated length of the column.

Consider a glued column under the action of a transverse load Q applied in a plane parallel to one of the planes of inertia and passing through the axes of the bending centers, and a longitudinal load N that preserves the direction when bending. At this loading, the column axis initially takes the form of a flat curve.

The equation of the curved axis of the column for longitudinal and transverse bending has the form:

$$v = v_0 + \theta_0 \frac{\sin kx}{k} + \frac{M_0}{k^2 EJ_z}(1 - \cos kx) + \frac{Q_0}{k^2 EJ_z}\left(x - \frac{\sin kx}{k}\right), \quad (1)$$

where $k = \sqrt{N/EJ_z}$, EJ_z- the rigidity of the cross-section of the wooden rod when bending.

Formulas for determining the angles of rotation of sections, bending moments and transverse forces are derived based on the differential dependencies between the main functions describing the stress-strain state of the column:

$$\theta = dv/dx; \quad (2)$$

$$M = EJ_z \frac{d^2v}{dx^2} = EJ_z \frac{d\theta}{dx} \quad (3)$$

$$\theta = \frac{dM}{dx} = EJ_z \frac{d^3v}{dx^3} \quad (4)$$

Where is the angle of rotation of the column sections

$$\theta = \theta_0 \cos kx + \frac{M_0}{KEJ_z} \sin kx + \frac{\theta_0}{K^2 EJ_z}(1+\cos kx),$$

Bending moment

$$M = EJ_z v'' = -kEJ_z\theta_0 \sin kx + M_0 \cos ks + \frac{\theta_0}{k} \sin kx \quad (5)$$

Lateral force

$$Q = EJ_z v'' = -k^2 EJ_z \theta_0 \cos kx + kM_0 \sin kx + Q_0 \cos kx. \quad (6)$$

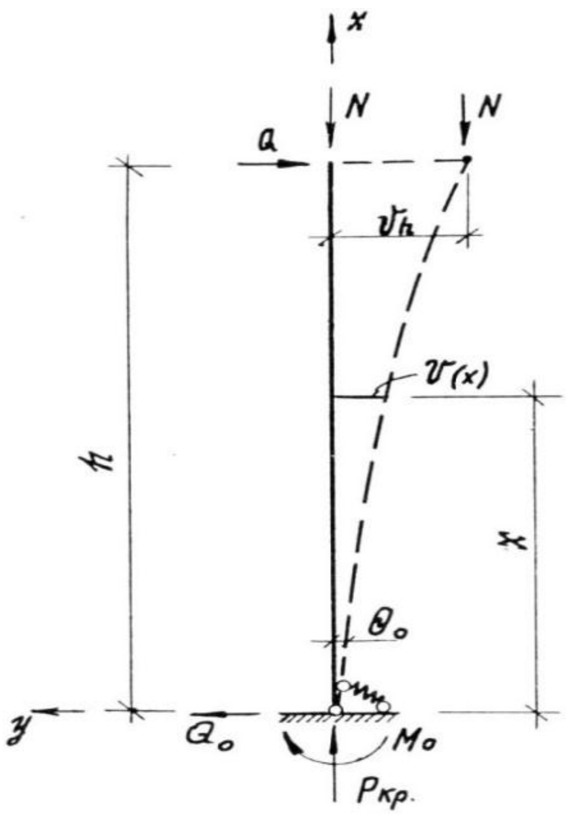

Figure 3. To determine the elastic pliability of support nodes.

Denoted $\theta_0 = M_0/C$ and substituting in equation 5 we get:

$$M = -K\frac{M_0}{c} EJ_z \sin kx + M_0 \cos kx + \frac{\sin kx}{k},$$

where C – the stiffness of the elastic pliable pinching.

Using a static and boundary condition M= $|_{x=h} = 0$ in the case of longitudinal bending (in the absence of transverse loads: ($Q_0 = 0$), have

$$\left(-\frac{kEJ_z}{c}\sin kh + \cos kh\right)\cdot M=0 \quad (7)$$

Then $tgkh = C/kEJ_z$, and after the conversion, we get,

$$kh\, tgkh = C\cdot h/EJ_z \quad (8)$$

There is no analytical solution to equation (7), but with a good approximation, given that the absolute values of can be obtained:

$$|k \cdot h| \le \frac{\pi}{2}$$

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$$tgkh \approx \frac{k \cdot h}{1 - \frac{4}{\pi^2} \cdot k^2 \cdot h^2} \quad \textbf{(9)}$$

Equating expression 10 to the value of the critical force for the hinge-supported rod $\mathcal{N}_{кр} = \pi^2 E\mathcal{J}_z / \mu^2 h^2$, after some transformations, we get an expression for the length reduction coefficient:

Then the calculated length of the column is determined by the formula:

$$\mathcal{N}_{кр} \approx \frac{1}{\frac{4 \cdot h^2}{\pi^2 \cdot E\mathcal{J}_z} - \frac{h}{C}} \quad \textbf{(10)}$$

$$\mu = \sqrt{4 + \frac{\pi^2 E\mathcal{J}_z}{h \cdot c}} \cong \sqrt{4 + 10\frac{E\mathcal{J}_z}{h \cdot c}} \quad \textbf{11)}$$

$$\mathrm{H} = \mu_0 h \quad \textbf{(12)}$$

II. CONCLUSION

From the expression (11), one can immediately see the influence of the pliability of the reference node in comparison with rigid $\mu_0 = 2$ nodes, which leads to an increase in the calculated length of the column.

Based on the data obtained, the following main conclusions can be formulated.

-the proposed method for calculating the stress-strain state of support nodes is based on the finite element method [4]. It allows you to accurately characterize the operation of these nodes under the influence of loads.

-the proposed solution of the problems allows us to determine the stress-strain state of the joint for any combination of loads, the results of which are in good agreement with the results of previous studies. The developed theory allows us to identify the calculated length of the column, taking into account the pliability of the nodes.

-based on the results of the method for determining the deformability of a reference node with metal stepchildren, expressions are obtained that accurately describe the deformed state of these nodes.

-the proposed method for calculating the stress-strain state of support nodes is based on the finite element method. It allows you to accurately characterize the operation of these nodes under the influence of loads.

-the proposed solution of the problems allows us to determine the stress-strain state of the joint on the glued rods for any combination of loads, the results of which are in good agreement with the results of previous studies.

- the developed theory allows us to identify the estimated length of the column, taking into account the flexibility of the nodes.

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