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Influence of Long-Term Loading and Central Asian Climate on Wooden Spatial Structures

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Influence of Long-Term Loading and Central Asian Climate on Wooden Spatial Structures

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Abstract: Modern construction, carried out in conditions of dry hot climate, is one of the most material-intensive industries. The article suggests the need to use available, comprehensive reserves to reduce material intensity, reduce labor and energy costs for the manufacture and construction of spatial wooden structures. In this regard, a solution to the problem with a wider use of lightweight materials, in particular wood, is proposed. Attempts are made to develop methods for calculating and designing spatial wooden systems. Issues related to the theory of deformation and resistances of wood under long-term impacts are considered. Data on the effect of humidity and temperature effects on wood in modern conditions of dry and hot climate are provided. The possibility of reducing material costs for the structure is attracted taking into account the long-term action of loads from 10 to 25%, a qualitative picture of the peculiarity of long-term deformation of wooden structures is explained.

Keywords: reduction of material consumption, deformation and resistance of wood, fibrous structure, elasticity, plasticity, amorphous viscous filler, anisotropically inhomogeneous material, humidity, temperature

INTRODUCTION

Increasing the efficiency of using wooden structures is closely related to such concepts as reliability and durability. However, these two indicators are not always ensured when using wooden structures under constant load and the action of the dry hot climate of Central Asia. Despite the widespread use of wooden structures, they do not always meet the strength and durability requirements under the above conditions due to the formation of damage in the form of parallel-fiber cracks and delimitation during operation. The geometric parameters of such damage, depending on the type of structure, the action of long-term load and operating conditions, vary widely, both in the depth of the section and the length of the structure. This is evidenced by the results of a literature review of a number of works by authors in which the problem of long-term loads and dry hot climate has not been studied sufficiently [1, 2, 3 and 4].

The specificity of wooden structures determines their unique scope of application, often where other materials do not meet the requirements, namely, the lightness of the material, the feasibility of using for large-span roofs, the need for which is increasingly increasing in modern conditions. This is especially relevant for regions with aggressive and harsh climates, when exposed to long-term loads. Resistance to aggressive environments, when exposed to long-term loads as large-span elements [3, 4].

It is known that wooden structures do not shrink evenly among all three sides (cross-section, radial and tangential sections, directions x, y and z). Whatever the type of wood, it shrinks the least along its grain z, i.e. per meter (0.1-0.4%), and the most along its cross-section (6-12%). Thermal conductivity of most wood materials under the influence of temperature (T) in a dry state is relatively insignificant. The thermal conductivity coefficient of wood through the cross-section is 0.17 W/m•°C, and along the radial and tangential grains - 0.34 W/m•°C. An increase in wood moisture content (W) increases its thermal conductivity. The ability of wooden structures to absorb moisture in space has a qualitatively negative effect on their strength and deformation. Therefore, it is important to determine the deformation and design resistance of wood over time under the influence of humidity and external temperature [5, 6, 7 and 8].

Since the resistance and deformation of wooden structures are affected by long-term constant loads, they have their own order of impacts, so that their natural structure cannot be changed. When exposed to humidity (W) and temperature (T), and then periodic long-term load, it is important to study the deformation of derivative structures and determine their design resistance, which is the main goal of the presented studies.

Normative and design resistance of wooden structures is closed in that ix resistance to the impact of periodic continuous external loads is removed to a certain extent with an increase in humidity.

As a result of increased air humidity on cold winter days, wooden structures tend to absorb moisture from the air. In some cases, due to excessive moisture absorption by wooden structures, their frame may freeze.

METHODOLOGY OF THE RESEARCH

Wood samples were taken from different species that are exposed to long-term constant load. The samples were chips of lumber of spatial structures. Species of samples are presented in Table 1. Standard samples were made from the chips to determine the moisture content, density and strength of wood. Wood moisture content was determined according to the method of GOST 16483.7-82, density – GOST 16483.1-84 and strength – GOST 16483.10-73, GOST 16483.23-73.

The determination of the ultimate strength for any given duration of load action was carried out using the formula [9]:

$$\sigma_\tau = \sigma_{\text{ст}} + \alpha(\log\tau_{\text{ст}} - \log\tau) \quad (1)$$

Where σ_τ is the ultimate strength at a given load duration, MPa; σ_{st} is the ultimate strength during standard tests, MPa; τ_{st} is the time required for the specimen to fail during standard tests, c; α is the correction number, MPa; The values of σ_{st} and α for different types of rock and force action are given in the Guidelines for Technical Materials (GTM) [15].

RESEARCH RESULTS AND THEIR DISCUSSION

As a result of the absorption of unbound excess moisture in space, the mass of wooden structures mechanically increases, their volumetric and linear dimensions increase. In addition, a decrease in the elastic modulus (E) of the wood material is observed under the influence of temperature (T) and humidity (W) (Fig. 1).

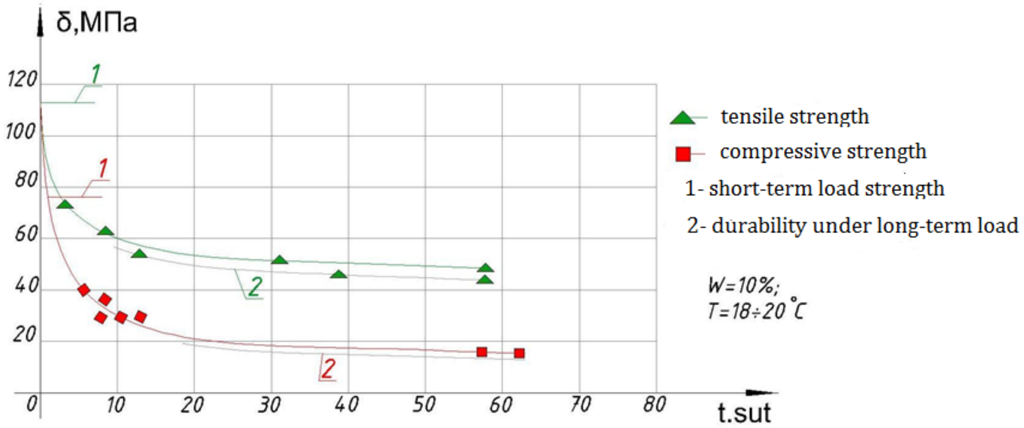

FIGURE 1. Tensile and compression strength limits of experimental wood samples under cyclic continuous loading in the direction of the fibers for a period of time (t)

As a result of the above-described monotonous process, repeated over many years, wooden structures become unusable before they reach their service life. Based on the results of the research, a decision was made to determine the standard and design resistance of structures made of wooden materials to tension and compression under the action of a centrally applied periodic continuous load.

Local damage (bending, cracking) occurs in the body of a wooden specimen under a relatively long-term continuous load along the direction of the fibers and in transverse sections. This phenomenon, in turn, has been found to occur over a short period of time.

The stages of strength of structures made of wood in central compression and tension over a period of time are given in table 1.

TABLE 1. Compressive and tensile strength limits along the fibers of samples taken from various types of wood

Type of wood materials	Type of test	Tensile strength, (R^*) МПа	Correction factors, α
pine (сосна)	compression	33,2	0,44
	stretching	56,4	0,52
beech (бук)	compression	31	0,47
	stretching	86,3	0,44
oak (дуб)	compression	43	0,6
	stretching	55,5	0,46
Native blue poplar	compression	36,52	0,42
	stretching	62,04	0,54
Local gio poplar	compression	31,5	0,40
	stretching	53,6	0,50
Native California Poplar	compression	30,0	0,42
	stretching	51,4	0,52

Since wood is considered an elastic material, the mechanical properties of the samples made from it, such as elongation or compression under a central continuous long-term load, bending under a transverse load, and bending under a shear force, were determined and various valuable results were obtained. Since most wooden elements are anisotropic (multidimensional) materials, they change from an elastic state to a plastic state under the action of a force applied to them. Therefore, the transition boundary from an elastic state to a plastic state was studied. In addition, the elastic module of wooden structures also changes during the studies, for example:

- modulus of elasticity along the longitudinal fibers of wood, *Ea*;
- in the direction transverse to the longitudinal fibers of wood (tangential modulus of elasticity) *Et*;
- in the direction radial to the longitudinal fibers of wood (radial modulus of elasticity) - *Er*;
- bending modulus of elasticity of wooden structures - E_{bend};

In the following tables (2), (3) we present all the data on the modulus of elasticity according to the types of wood materials used in the studies.

TABLE 2. Modulus of elasticity according to types of wood materials

Type of wood materials	Long-term compressed element, MPa			Long-term stretch element, МПа			Statically bending element, $E_{bend,}$ МПа
	E_a	E_t	E_r	E_a	E_t	E_r	
pine (сосна)	12100	570	690	12100	500	580	12600
beech (бук)	14500	430	660	14600	490	690	11000
oak (дуб)	14300	9770	1340	14300	890	1160	15400
birch (тус)	16100	520	670	18300	490	670	15400

TABLE 3. Deformation coefficients according to the types of wood used in the research, μ

Type of wood materials	deformation coefficients, μ					
pine (сосна)	0,49	0,41	0,03	0,79	0,037	0,038
birch (тус)	0,58	0,45	0,043	0,81	0,04	0,49
oak (дуб)	0,43	0,41	0,07	0,83	0,09	0,34
Spruce (ель)	0,44	0,411	0,017	0,48	0,031	0,025

As is known, wooden products (structures) have not been fully studied to date in terms of mechanical strength and long-term constant load.

According to the research results, it can be noted that: - as a result of increasing deformations of wooden structures under the action of constant loads at a moisture content of the internal structure of wood of more than W > 12%, the phenomenon of slippage or creep of cell membranes under the action of water pressure in the fiber capillaries may occur. In this case, the thin walls of the wood capillaries undergo elastic deformation, and the skeleton of the fibers in the system is deformed. Based on this property of wood, an assumption was made about the presence of elastic-plastic or elastic-sliding deformation in wood [9, 10, 11,12, 13 and 14].

According to the basic theory, the following function can be expressed as a function of the dependence of tension, deformation and time:

$$\varepsilon(t)=\varphi[\delta(t):\ t\ \text{ва}\ \tau] \qquad (2)$$

here $\varepsilon(t) - t$ is the total relative deformation produced in the time interval $t\delta(t)$ is the stress at any instant of time; t is time; τ is the calculated time coordinate.

DISCUSSIONS

Based on the creep theory, the following concepts and hypotheses were formulated regarding wood deformations under constant long-term load:

- despite the fact that wood is an anisotropic material by its nature, in calculations we assume it to be a homogeneous rigid material;

- we assume that wood is a heterogeneous anisotropic material with non-uniform fibers, sometimes directed in different directions, with uniform deformation indices depending on the action of forces perpendicular to the trunk or at an angle;

- the following relationship exists between the total deformation of wood (elastic deformation and creep deformation) and stress:

- there is a linear relationship between stress and creep deformation;

- there is a negligible relationship between stress and creep deformation;

- it is assumed that the absolute value of deformation depends on the sign of (inelastic) stress;

- it is assumed that creep deformation, as well as elastic deformation occurring at the given moment, is determined by the law of loading. Studies of deformation of wooden structures under long-term action of loads have shown that wood is considered a linearly creeping material in cases where its strength does not exceed the tensile strength, and taking into account the above assumptions and suppositions, linear creep of wood is determined. - for the first time for long-term loaded wood, the relationships between stress intensity factors and tangential stresses, as well as rapid crack propagation under combined action on tension or tearing, are determined.

The possibility of reducing the cost of materials for the structure taking into account the long-term action of loads from 10 to 25% has been established, and a qualitative picture of the peculiarity of long-term deformation of wooden structures has been explained.

REFERENCES:

1. K. P. Pyatikrestovskiy, Sustained force deforming of structured materials, Structural Mechanics of Engineering Constructions, (2017). - journals.rudn.ru.
2. S. I. Roshchina, A. Y. Naichuk, The effect of eccentricity on the strength characteristics of glued rods made of steel cable reinforcement in solid wood, IOP conference series …, (2020) - iopscience.iop.org.
3. A.D. Platonov, T.K. Kuryanova, Increasing the service life of sleepers made from birch wood, Series: Earth and …, (2019) - iopscience.iop.org.
4. S. Svensson, S. Thelandersson and H. J. Larsen, Reliability of timber structures under long term loads //Materials and Structures/Matériaux et Constructions, Vol. **32**, pp 755-760, (1999).
5. S. Kulman, L. Boiko, & J. Sedliačik, Long-term strength prediction of wood based composites using the kinetic equations. Scientific Horizons, **24**(3), 9-18, (2021).
6. J. D. Barrett, and R. O. Foschi, , 'Duration of load and probability of failure in wood, part I and II', *Canadian Journal of Civil Engineering* **5** (4) 505-532, (1978).
7. Yu. N. Rabotnov, On the mechanism of long-term destruction. Strength Issues of Materials and Structures, **7**, 5-7, (1959).

8. A. N. Oblivin, I. V. Sapozhnikov & M. V. Lopatnikov, Simulation of long-term strength of composite materials with wood filler. Forestry Bulletin, **1**, 6-11, (2015).
9. S. Kulman, & L. Boiko, Kinetic model of long durability of porous composite materials based on wood. Modern Structures of Metal and Wood, **19**, 79-85, (2015).
10. J. Winandy, Relating wood chemistry and strength: Part II. Fundamental relationships between changes in wood chemistry and strength of wood. Wood and Fiber Science, **49**(1), 2-11, (2017).
11. N. F. Bakhriev, N. R. Qurolova, Composite Wave Sheets from Basalt Fiber for Pitched. Lecture Notes in Civil Engineering, **369**, pp.3–17, 2024.
12. B. N. Fakhritdinovich, Q. N. Ravshan kizi, Raw Mixture for Forming Flat and Wavy Sheet, Uz Fap 02222 Byul., No. **3**, (2023).
13. N. Bakhriev, Z. Fayzillaev, Modeling the optimal compositions of dry gypsum mixtures with bio-vegetable fillers, research of their adhesion properties, AIP Conf. Proc. 2657, 020029 (2022), https://doi.org/10.1063/5.0106902.
14. N. F. Bakhriev, N. R. Qurolova, Composite wave sheets from basalt fiber for pitched roofing, Research and Developments in Engineering Research, Page 15-32, https://doi.org/10.9734/bpi/rader/v3/5399C.
15. Wood. Indicators of physical and mechanical properties. RTM. - M.: Committee of Standards under the USSR Council of Ministers, 48 p. (1962).

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