Determination of the natural oscillation frequency of the structural unit of covering by the action of the shock load

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Abstract. The article presents the results of experimental studies of the wood-metal spatial structural unit-TTMBF-18.6. We should monition, that wood attracts designers both by its resistance to aggressive media, and by its physical properties and strength characteristics. This material has a high deformability and specific viscosity, which allows it to absorb shocks and vibrations, making it an excellent material for use in regions with increased seismic activity. The aim of the work is to obtain the frequencies of natural vibrations for the subsequent study of the dynamic characteristics of the structure. The article describes the advantages of wooden structures. The methodology of the full-scale experiment and the results of research are given. Our data obtained allow us to study the nature of the stress-strain state of structural elements during dynamic loading and in the future to obtain a dynamic design coefficient, which will help to develop a methodology for calculating structures for dynamic effects.

1. Introduction

Wooden construction is one of the most urgent ways to develop the construction industry, especially in areas of Eastern and Western Siberia and the Far East, where the timber industry is most developed. In recent years, thanks to the experience of Europe, there has been an increase in interest in the use of wood and the spread of “green” construction in Russian Federation. The construction of wooden buildings implies not only residential, but also public and industrial buildings.

It should be noted that the designers of wooden structures, buildings and structures commissioned not only low-rise buildings, but also large-span buildings with elements made of wood and wood materials. An example is the building of the “Kva-kva” water park in Moscow, Mytishchi district.

The choice of glued wood as a material for water parks is due to the requirements for the durability of the roof, which must work in a humid chlorine-containing environment for 50 years or more, withstanding the thermal loads of both internal and external environments.

Wood attracts designers both by its resistance to aggressive media, and by its physical properties and strength characteristics. Wood has a high deformability and specific viscosity, which allows it to absorb shocks and vibrations, making it an excellent material for use in regions with increased seismic activity. When designing buildings in seismically active regions, one should determine the value of natural oscillation frequencies of building structures and give them appropriate shapes. The determination of the natural oscillation frequencies of building structures is necessary for the analysis of the dynamic behavior of the structure under the action of variable loads, which in the future will help to avoid such a mechanical phenomenon as resonance. A multiple increase in the amplitudes of oscillations at resonance and the resulting high levels of tensions are one of the main causes of the destruction of buildings and structures operated under seismic and dynamic loads.
In connection with the above arguments, it was decided to study the work under the action of dynamic loads and to determine the natural frequency characteristics using the TBFD 18.6 wood-metal structural block as an example (figure 1).

The wood-metal structural block of the coating TBFD 18.6 consists of two block-trusses TBFD 18.3, united in the middle of the span and having a double chord. The span is 18 m, width 6 m, construction height in the middle of the span 2.293 m. The span of the block-trusses is reduced to a standardized column pitch of 6 m. The design can be used in coatings of industrial and agricultural buildings, as well as sports facilities [1].

Specialists of Tomsk State University of Architecture and Civil Engineering were invited to conduct the tests. The values of the dynamic parameters were obtained by field measurements using an RSV-150 laser vibrometer and processing the results using VibSoft-20 software.

2. Test methodology

It was planned to measure the dynamic parameters of the structural block in several stages by applying a concentrated shock load to the ridge nodes, simulated by tensioning a static rope under various static loads (figure 2).

Figure 1. The structural block TBFD-18.6.

Figure 2. Scheme of application of dynamic load to the structural block brand TBFD-18.6.

Nodal loading was carried out by tensioning a manual mechanical hoist fixed at one end to the floor of the test hall and at the other end fixed to a static rope to the top chord of the structural block. Manual hoist tension was performed until loading reached 800 kgf. The control of the magnitude of the loading was carried out by electronic scales VSK-1000A. Upon reaching the required load, the
rope was cut, thereby exciting free harmonic oscillations of the structure. The vibrations obtained in this way can be called “strings”. The oscillations were excited in several stages with a static load simulating the amount of snow cover on the structural block of the coating. The loading step was 3.5 tons, the number of steps – 4. In the process of testing, measurements were made of the frequency characteristics of the structure under free oscillations. The dynamic parameters were recorded with a RSV-150 laser vibrometer in the measurement range from 0 to 10 Hz. Measurements were taken at one point in the structure.

![Graph of displacements versus frequency under a load of 10.5 t.](image)

According to the test results, dynamic parameters of the structures were obtained in the form of natural frequency spectra for each loading stage. The values of the natural frequency spectra are presented in the table.

| №  | Node  | Load, t | Frequency, Hz |
|----|-------|---------|---------------|
| 1  | RMN* | 0       | 4.26          |
| 2  | REN* | 0       | 4.25          |
| 3  | RMN* | 3.5     | 3.5           |
| 4  | REN* | 3.5     | 3.55          |
| 5  | RMN* | 7       | 3.05          |
| 6  | REN* | 7       | 3.05          |
| 7  | RMN* | 10.5    | 2.8           |
| 8  | REN* | 10.5    | 2.73          |
| 9  | RMN* | 15      | 2.45          |
| 10 | REN* | 15      | 2.46          |

RMN* - ridge median node.
REN* - ridge outside node.

3. The results of the study
1. Under the influence of a dynamic load on a structural block, regardless of the point of application, the values of the natural frequencies have similar values.
2. The values of the natural oscillation frequencies at various loads are obtained, which allows for further comparison with numerical studies of the structural block of the coating.

3. The data obtained allow us to study the nature of the stress-strain state of structural elements during dynamic loading and in the future to obtain a dynamic design coefficient, which will help to develop a methodology for calculating structures for dynamic effects.

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