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RESEARCH OF PARAMETERS OF THE PROTECTING DESIGNS INFLUENCING RESONANT AND INERTIAL PASSAGE OF SOUND

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The article is about theoretical and experimental researches of sound insulation of protecting constructions. Experiments were carried out in large and small reverberation chambers of the acoustic laboratory of NNUACE on gypsum-fibrous sheets. Theoretical researches of sound insulation of protecting designs were spent on the basis of the theory of the self-coordination of wave fields developed by professor M.S.Sedov's school. The given theory establishes the dual nature of passage of a sound - resonant and inertial. Resonant passage of a sound is defined by the degree of the self-coordination of a wave field of its fluctuations of a plate and sound fields from "noisy" and "silent" premises, and also losses of energy on dispersion. For protections of the set weight by the inertial passage of a sound can be operated by changing its sizes in the plan. The results of the researches on the definition of influence of edges of rigidity on sound insulation of protections are presented. The obtained data are coordinated with results of researches for other types of single-layered protections.

In practice of modern construction protection against noise in civil and industrial buildings is one of the most actual problems. In particular it is caused by occurrence of new protecting designs and materials, which are applied without a corresponding theoretical substantiation of their acoustic characteristics. It leads to rise in price of civil work, and necessary protection against noise is not provided, or provided with low efficiency. In this connection research of soundproofing properties of protecting designs is an actual problem.

Theoretical researches of sound insulation of protections are conducted under the theory of the self-coordination of wave fields (SCWF) professors M.S. Sedov [1], [2]. In a basis of this theory the dual nature of passage of a sound - resonant passage and inertial lays. Considering, that the characteristic of sound insulation is the factor of passage of a sound t, expression for definition of sound insulation can be presented in the form of:

$$R = 10\lg\frac{1}{\tau_I + \tau_R}, \tag{1}$$

Resonant passage is defined by a degree of passage of a sound through a protection in a mode of own fluctuations and established on size of amplitude of cross-section displacement of a plate. In the important parameter describing passage of a sound in a resonant mode, the characteristic of the self-coordination of wave fields, which depends on a parity of wave parameters of a sound field m_0, n_0 and fields of a plate m, n is.

$$A = \frac{\int_0^a \int_0^b \sin\frac{m\pi x}{a}\sin\frac{n\pi y}{b}\sin\frac{m_0\pi x}{a}\sin\frac{n_0\pi y}{b}\,dxdy}{\int_0^a \int_0^b \sin^2\frac{m_0\pi x}{a}\sin^2\frac{n_0\pi y}{b}\,dxdy}, \tag{2}$$

Consideration of the mechanism of resonant passage of a sound allows to define three basic cases of a parity of these parameters in which the response of a plate will be the greatest: $m \neq m_0$, $n \neq n_0$; $m = m_0$, $n \neq n_0$ или $m \neq m_0$, $n = n_0$; $m = m_0$, $n = n_0$.

According to the given parities all frequency range is divided into five areas: pre-resonant area, area of simple resonances (SR), area of simple space resonances (SSR), area of incomplete space resonances (ISR) and area of complete space resonances (CSR). On frequency SSR vectors of speed of sound waves in a plane of a plate and own waves discorded, but are in such parity among themselves, that the amplitude of displacement of a plate has the greatest value. In case of ISR speeds of sound waves in a plane of a plate and free waves on one party of a plate are equal among themselves, and on other party are in such attitude, that the response of a plate the greatest. And, at last, case CSR comes, when there is a full self-coordination of wave characteristics. That to design an effective soundproofing design it is necessary to define key parameters defining intensity of resonant and inertial passage of a sound.

The factor of resonant passage of a sound is defined under the formula:

$$\tau_c = \frac{1}{\frac{\pi^3 \cdot 1{,}15}{8 \cdot \rho_0^2 c_0^2 \cdot A_0^4} \cdot m'^2 \eta \cos\theta_{cp} \cos\theta_{2c} + 1}, \qquad (3)$$

where: $\rho_0 c_0$ - a characteristic impedance of environment $\frac{Pa \cdot s}{m}$; A - the characteristic of the self-coordination of a wave field of own fluctuations of the panel and sound fields from both parties of the panel; μ - superficial density of a material, kg/m^2; f - frequency of a sound, Hz; η - factor of losses of a material; Θ_{av} - 51,75 … ^{0} - an average corner of falling of waves diffused a sound field on a protection; Θ_{2C} - a corner of radiation of sound waves free waves of the panel;

From the formula (3) it is visible: to lower resonant passage of a sound through a protection it is necessary to reduce the characteristic of the self-coordination, to increase factor of losses or superficial weight of a protection, but the last will be not always rational, as with increase in superficial density of a protection loading on a design of a building will increase. On fig. 1 frequency characteristics of factor of resonant passage for duralumin sheets depending on factor of losses [3] are presented. Apparently from comparison of schedules the increase демпфирования protections promotes decrease in resonant passage of a sound.

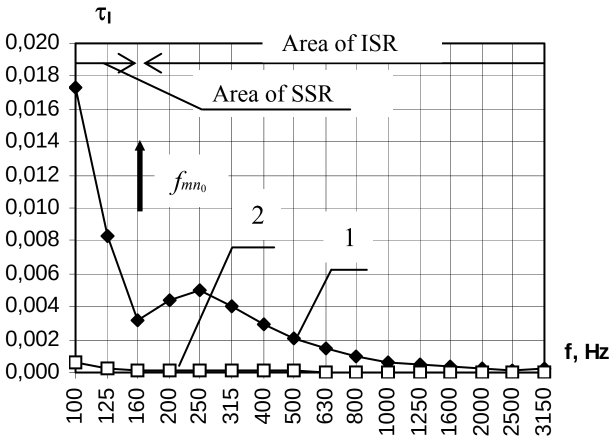

Fig. 1. Frequency characteristics of factor of resonant passage of a sound of a duralumin plate (a = 1,2 m, b = 1,0 m, h = 2 mm, D = 51,63 Pa·m^3) 1 - η = 0,002, 2 - η = 0,056;

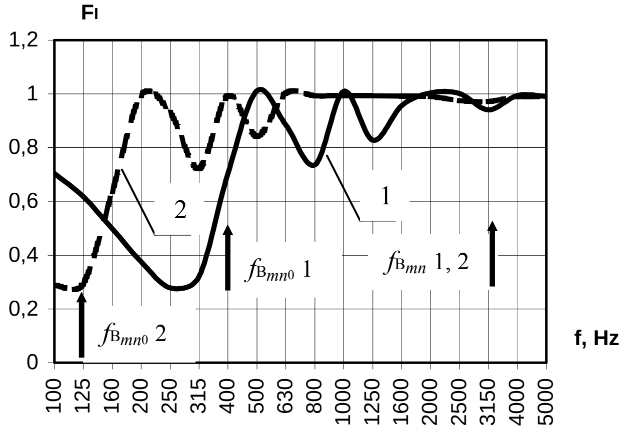

Fig. 2. The frequency characteristic of function of response gypsum-fibrous sheets (D = 762,93 Pa·m^3; m$'$ = 13,75 kg/m^2, h = 12,5 mm, η = 0,02) 1 - a = 1,0 m, b = 0,5 m, 2 - a = 2,5 m, b = 1,2 m;

In an inertial mode the model of passage of a sound is supplemented with some initial oscillatory condition of a plate previous during each moment of time to process of resonant passage [4]. Sound insulation will be defined in this case by superficial density both μ and size of function of response F_I. But as regulation in superficial density not always rationally has noted been above, hence, effective parameter of management of inertial passage of a sound is function of the response.

Regulation in size F_I is possible by change of the sizes of a design by way of. On fig. 2 frequency characteristics of function of the response of two protections differing only are resulted by the geometrical sizes. On the resulted schedules influence of the sizes of a protecting design on function of the response of a protection and, hence, on size of inertial passage of a sound is clearly visible.

Experimental researches which confirm conclusions of theoretical researches lead according to the theory of the self-coordination of wave fields have been lead to laboratories of acoustics NNUACE. Decrease in passage of a resonant sound for a duralumin plate due to increase in factor of losses (fig. 1) has allowed by addition vibroabsorbing a layer to a plate essentially to raise its sound insulation in all ranges of frequencies (fig. 3).

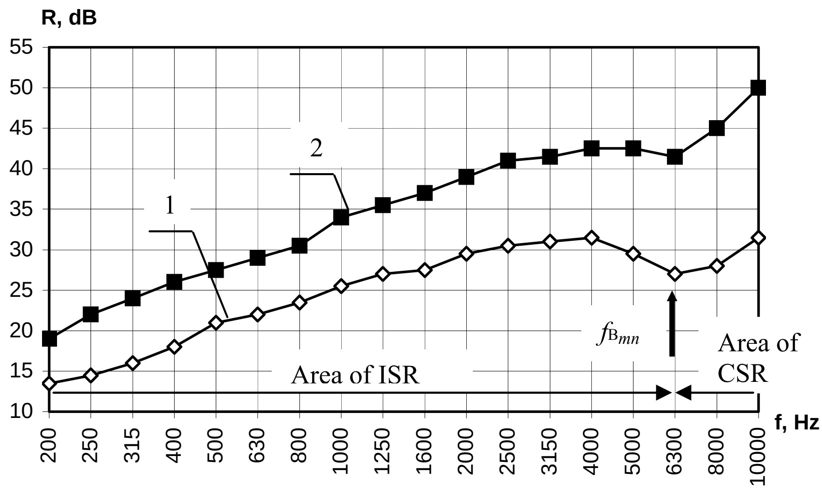

Fig. 3. Frequency characteristics of sound insulation of protections (a = 1,2 m, b = 1,0)
1 - duralumin of 2 mm, μ = 0,002, 2 - duralumin of 2 mm + Agate of 6 mm, μ = 0,056;

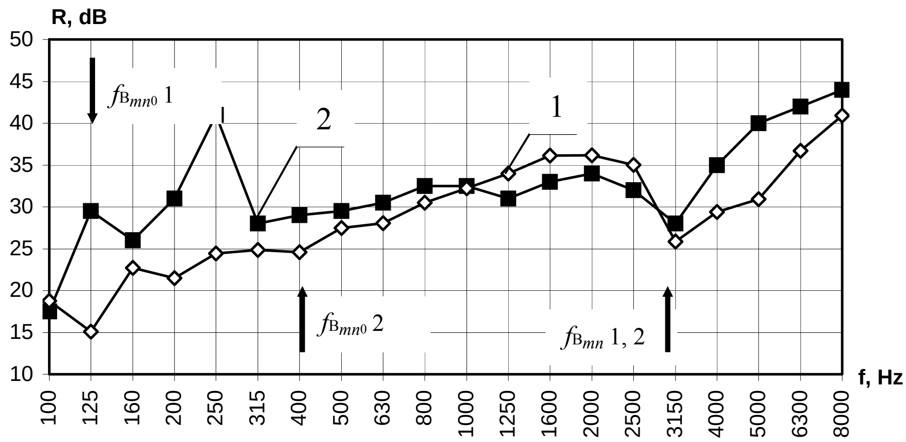

Fig. 4. Frequency characteristics of sound insulation gypsum-fibrous sheets
(D = 762,93 Pa·m^3, m$^/$ = 13,75 kg/m^2, h = 12,5 mm) 1 - a = 1,95 m, b = 1,13 m,
2 - a = 1,0 m, b = 0,5 m;

In experiments with gypsum-fibrous sheets [5] (fig. 4) is distinctly traced influence of the sizes of a design by way of on its sound insulation, that confirms influence of function of the response (fig. 2) especially in the field of low frequencies. In laboratory of acoustics NNUACE also have been carried out researches by definition of influence of edges of rigidity on sound insulation of protecting designs [6]. In an acoustic aperture of laboratory gypsum-fibrous sheets by thickness of 12,5 mm were established. On investigated protections edges from steel thin-walled curved a structure with section in the form of a channel, height of section 50 of mm were mounted. Following samples were investigated: a leaf with one structure - type 1, with three structures - type 2 and with the structures established crosswisely - type 3 (fig. 4). To samples all edges fastened by means of epoxide glue, which provided rigid connection of samples, that as much as possible provided teamwork of a leaf and a structure.

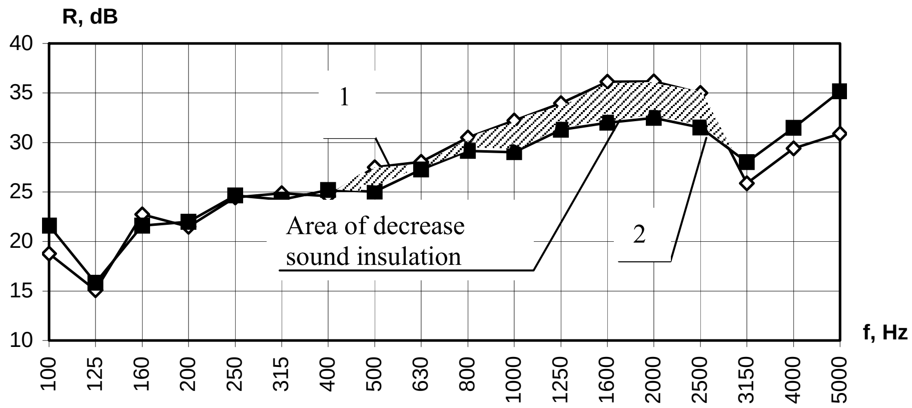

Fig. 4 Frequency characteristics of sound insulation of the tested designs: 1 - a leaf without edges, 2 - type 3

Analyzing the received results of sound insulation of the tested designs it is possible to see, that edges of rigidity have slightly lowered sound insulation of a protection. Distinctly decrease can be seen only in the field of average and high frequencies. On frequency of 2500 Hz it reaches the maximal value - 4 dB. Such insignificant effect speaks that rigidity of a leaf at an attachment on it of edges has grown all in 25 times and downturn of sound insulation has made insignificant size. Data of experiment confirm, that decrease in sound insulation of a protection occurs to increase in its rigidity. From this it is possible to draw a conclusion that at correct selection of rigidity reception of protecting designs, which can correspond necessary rigid to parameters at insignificant decrease in soundproofing properties, is possible.

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