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Graphical Method for Calculating Sound Insulation of Air Noise of Single Layer Enclosing Structures

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ABSTRACT: Graphical method for construction of frequency characteristics of enclosing structures of sound protection by the method of calculating the sound insulation of single layer mass enclosing structures.

KEYWORDS: sound insulation, graphical method, construction, frequency, enclosing structures.

I. INTRODUCTION

One of the conditions for comfort of building is to ensure a favorable acoustic regime in the premises, which is largely achieved by the correct choice of walling at the design stage.

Presently, the most profitable and structurally appropriate in multi-story buildings is the use of single-layer enclosing and load-bearing structures made of dense materials. The graphic method available in [2, 4] for constructing the frequency response characteristics of airborne sound insulation was developed for fences made of existing materials based on the statistical processing of a large number of experimental data.

Based on many years of research at Moscow state construction university, a method has been developed for calculating airborne sound insulation with single-layer enclosing structures in the normalized frequency range [1, 3]. According to the calculation method, a graphic method has been developed for determining air noise of sound insulation, which is used to build octave insulation spectra with single-layer fences made of concrete, reinforced concrete, brick, ceramic blocks and the like, with dense materials with a surface density of 50 to 1000 kg / m^2[5]. This method is designed to assess the sound-insulating ability in the design of new building envelopes, as well as for comparison with the results of field tests and the standard frequency response. The interface of the fence with adjacent structures must be tight without elastic inserts and hinges. The design range is above the third Eigenfrequency of the bending vibrations of the enclosure concerned.

II. METHODS OF RESULT

The frequency response of airborne sound insulation is depicted as a broken line **ABCDE** (Fig. 1). The coordinates of the cutoff frequency of the wave coincidence (point C) of the frequency response should be determined from the graphs shown in Fig. 2.

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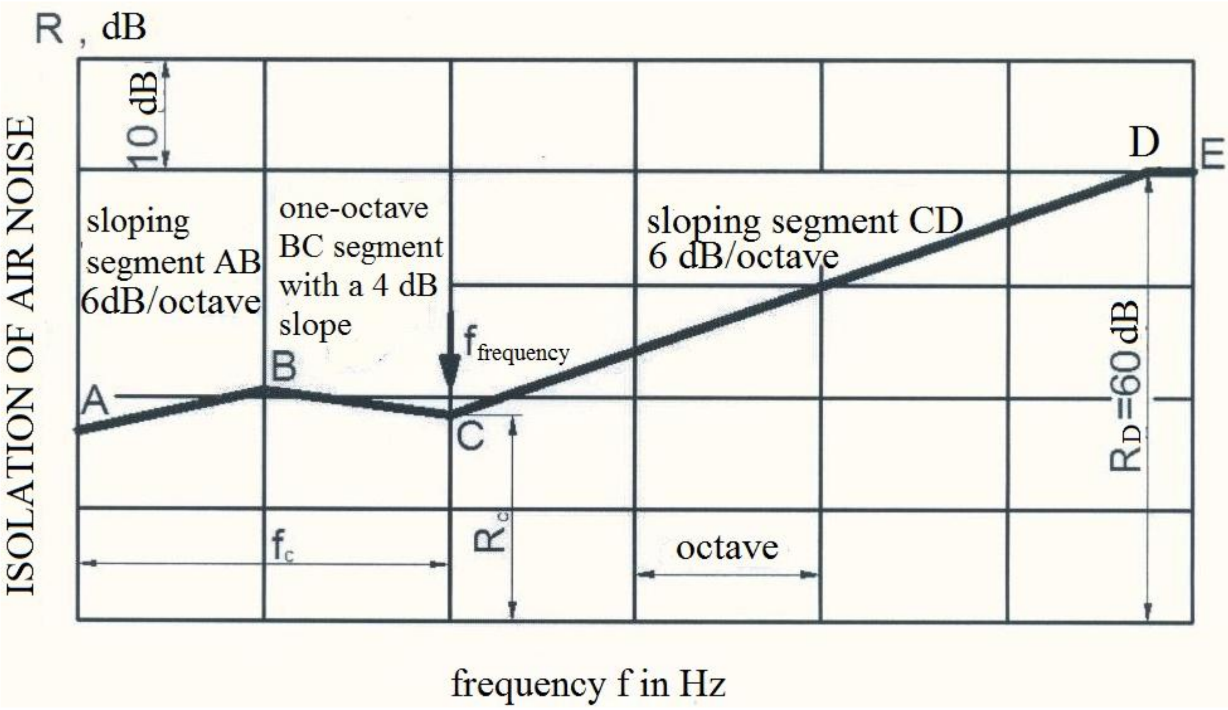

Fig.1. Frequency response of air noise of sound insulation with a single layer enclose

The abscissa f_C is determined depending on the thickness ***h*** (m) of the building envelope and the velocity of the longitudinal waves $\mathbf{C_{range}}$(m/s). This frequency is equal to the geometric mean frequency of the octave band within which it is located (Fig. 2, a). The ordinate R_C is determined depending on the surface density***m***(kg / m^2) and the boundary frequency of the wave coincidence $f_C$enclosing structure (Fig. 2b). The velocity of longitudinal waves is determined by the well-known formula:

$$C_{range} = \sqrt{\frac{E}{\rho(1-\upsilon^2)}} \quad , \quad m/s (1)$$

where,E— accordingly elastic modulusH/m^2, and ρ- material density kg/m^3 structure;υ — Poisson's ratio.

a)

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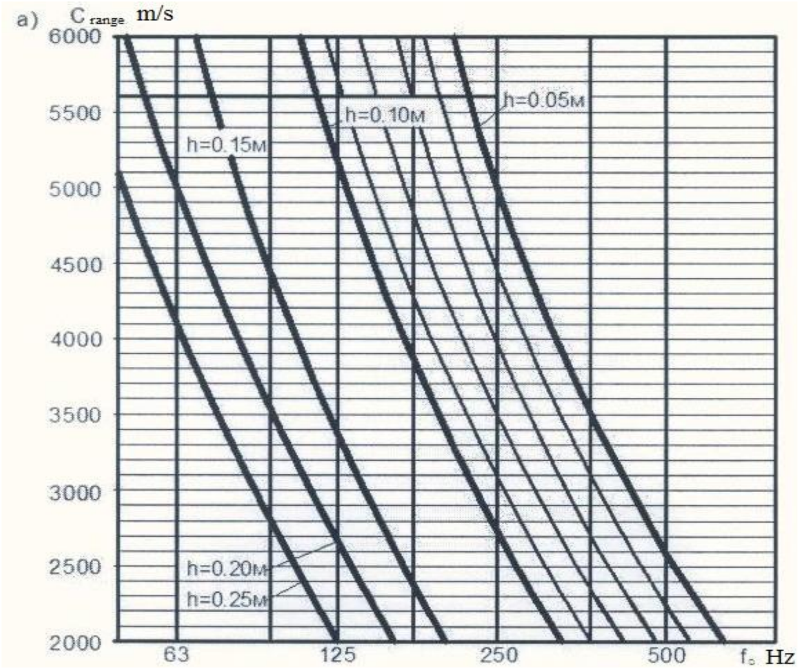

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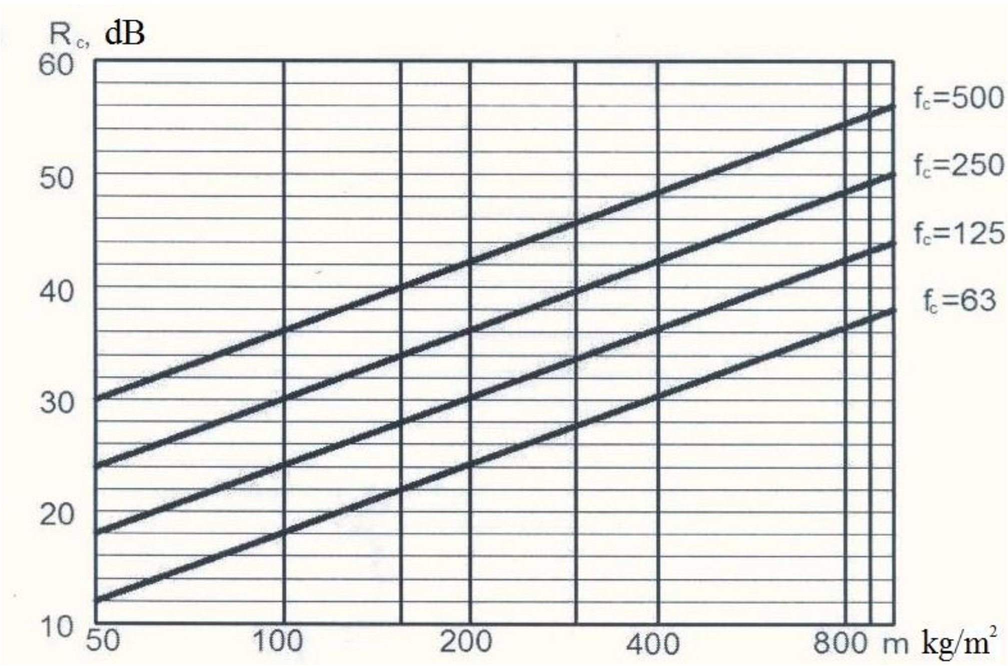

Fig. 2. Graph for determining the coordinates of point C:

a - to determine the coordinatef_C; b-to determine the coordinates of R_C

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The frequency response of airborne sound insulation is constructed as follows: from the left point, the segment of the aircraft is drawn one octave with a slope of 4 dB per octave, then from the point to the left, the segment **AB** is drawn down with a slope of 6 dB per octave, from the point **C** to the right, the segment of the light beam is drawn with a slope of 6 dB per octave to point **D** with an ordinate R_D = 60 dB, after which the isolation value is assumed to be constant and is represented by a horizontal segment **DE**.

As an example in fig. Figure 3 shows the frequency characteristics of airborne sound insulation of a partition made of silicate blocks measuring 498x250x498 mm and a density of 1800 kg / m^3 measured in the laboratory of the Research institute of building physics of the Russian academy of architecture and construction sciences designed for interroom partitions and external walls, as well as walls made of aerated concrete blocks 600x300x200 mm in size, grade D600, taking into account plaster layer of cement-sand mortar 340 mm.

The tests of cellular concrete blocks were carried out in the testing laboratory of Central analytical laboratory for Energy saving in Construction complex in Kazan.

The tests were carried out in accordance with the requirements of NST 27296-2012 “Buildings and structures. Methods for measuring the sound insulation of building envelopes ".

We construct the frequency response of airborne sound insulation by the proposed method. From the graphs in Fig. 2 we find the coordinates of point C. Depending on the velocity of the longitudinal waves calculated by the formula (1), C_{range} = 3550 m / s and the thickness of the fencing h = 25 cm ($f_C$is 63 Hz, $R_C$depending on the surface density m = ρh = 450 kg / m^2 and the limiting frequency of the wave coincidence f_C is 32 dB. Next, from the point C to the left, draw a segment of the aircraft one octave with a slope of 4 dB, and to the right, the segment of the CD with slope of 6 dB / octave to point D with the ordinate R_D = 60 dB and horizontal section DE. The obtained frequency response is shown in the same figure. As can be seen from the figure, the calculated the frequency response is in good agreement with field measurements.

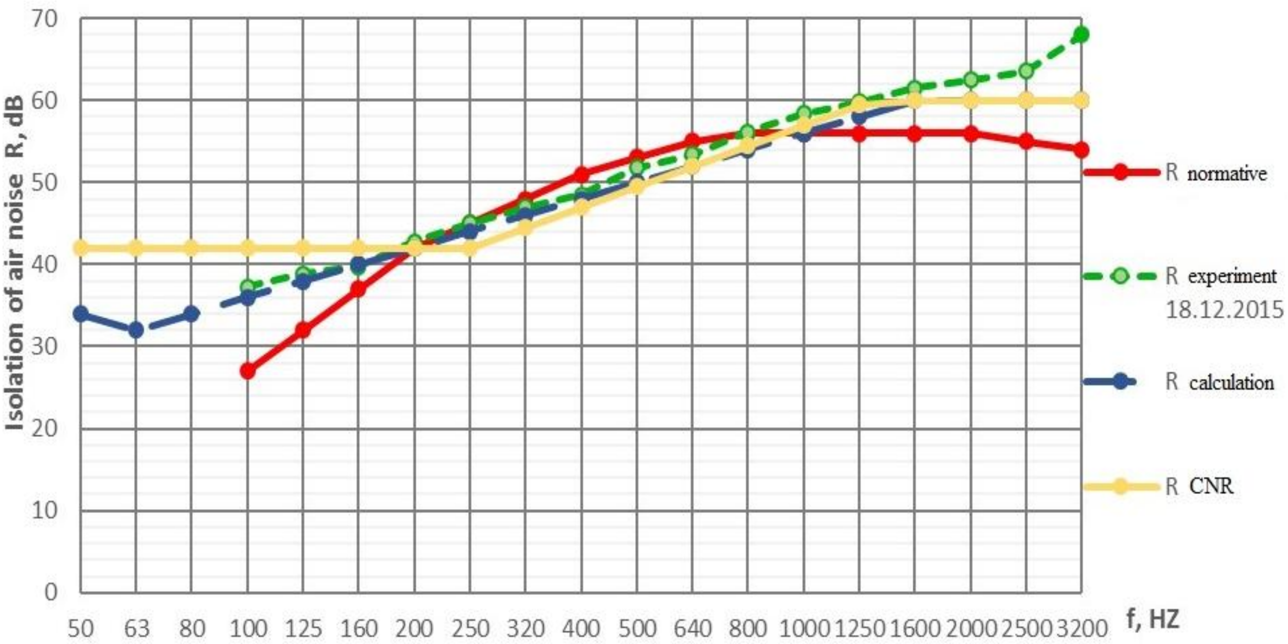

Fig. 3. Frequency characteristics of airborne sound insulation of a partition made of silicate blocks with dimensions of 498x250x498 mm and a density of 1800 kg / m^3

Using the same method, we construct the frequency response of airborne sound insulation for another building envelope. From the graphs in Fig. 2 we find the coordinates of point **C**. Depending on the velocity of the longitudinal waves calculated by the formula (1), $\mathbf{C_{range}}$= 3200 m / s and the thickness of the fencing ***h*** = 30 cm ($\boldsymbol{f_C}$is 63 Hz, $\boldsymbol{R_C}$depending on the surface density m = ρ*h* = 540 kg / m^2 and the cut-off frequency of the wave coincidence $\boldsymbol{f_C}$is 32 dB. Next, from the point **C** to the left, draw a segment of the aircraft one octave with a slope of 4 dB, and to the right, a segment of **CD** with a slope of 6 dB / octave to point **D** with an ordinate **RD** = 60 dB and horizontal section **DE**.

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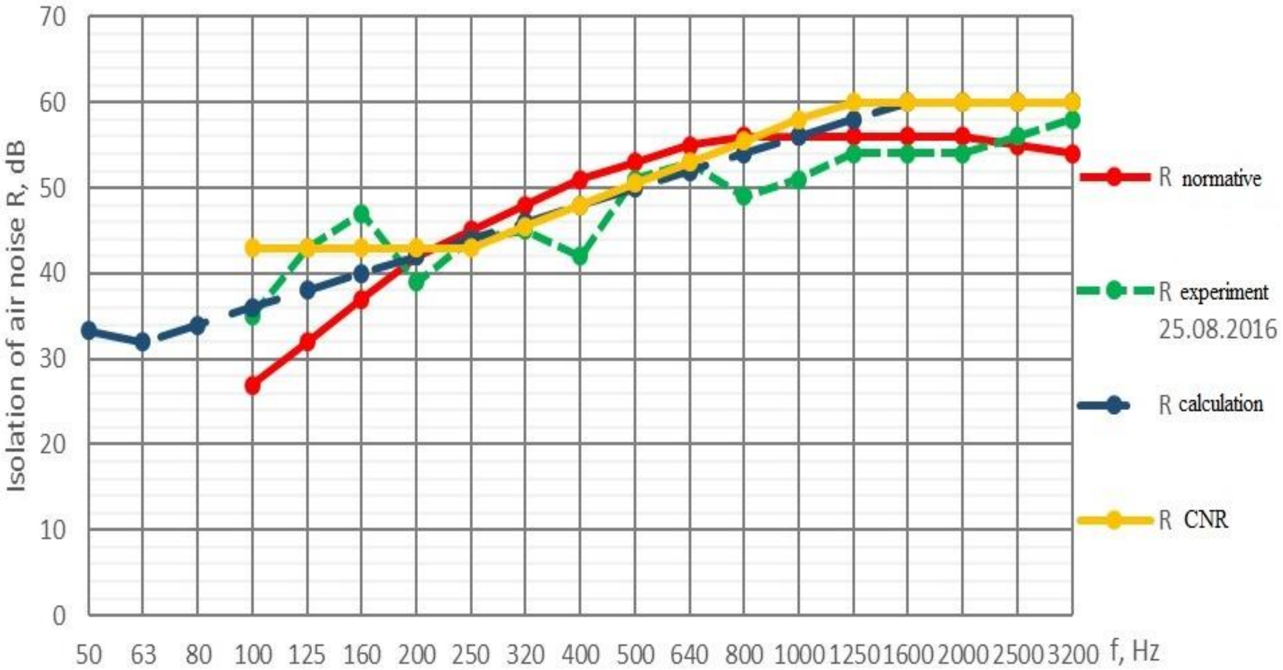

Fig. 4. Frequency characteristics of airborne sound insulation of a cellular concrete partition with dimensions of 600x300x200 mm and a density of 1800 kg / m^3

III. CONCLUSION

Consequently, assess sound-insulating ability of single layer walling at the design stage, we can use the proposed graphical method.

Numerous calculations and comparisons with natural measurements showed the reliability of this method.

Comparison of the calculated theoretical frequency characteristics with the normative allows the designer to choose the enclosure of buildings with predefined sound insulation characteristics.

This provides significant savings for assessing the sound insulating ability of building envelopes without spending the cost of laboratory tests.

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