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Calculation And Design Acoustic Conditions Of Multipurpose Hall

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ABSTRACT

One of the important problems facing the architect is to create favorable acoustic comfort for the hall, which can be ensured by meeting the basic requirements architectural and construction acoustics, when developing a rational space-planning solution.

The research paper discusses the calculation and design of the space-planning solution of multipurpose hall located in the city of Navoi, which provides optimal natural acoustics.

KEYWORDS

Acoustic comfort, calculation, design, noise, multipurpose hall, space-planning solution, properties.

INTRODUCTION

At present almost all large halls are equipped with a sound reinforcement system, but for a number of halls the requirements are imposed on optimal acoustic conditions without sound reinforcement [1].

Ensuring the acoustic comfort of the hall depends on the following important tasks [2,3]:

- The reverberation time of the projected room differs from the recommended one by no more than 10%;
- The maximum possible sound pressure level of the usable sound is required at the seating position;
- Choose the shape and outline of the internal surfaces, providing both the formation of the first low-range sound reflections and the required degree of diffuseness of the sound field;
- To prevent the concentration of sound, which can lead to the formation of curved surfaces of small radius, as well as to avoid other acoustic defects.

The correct ratio in the distribution of direct and reflected sound energy, as well as the creation of a diffuse sound field, is achieved by making the right choice:

- The size of the hall and its capacity;
- Mutual placement of the stage and spectator seats;
- Profile and location of reflective surfaces and individual architectural elements;
- Quantity, properties and placement of sound-absorbing material.

METHODS OF RESEARCH

The calculation of the acoustic comfort of the multipurpose hall of the existing capacity of the hall for 800 people located in the city of Navoi was designed in accordance with the regulatory documents KMK 2.01.08-19 "Protection against noise" of the Republic of Uzbekistan.

The multipurpose hall has a stage box, but its total volume is taken without taking into account the volume of the stage. The volume of the number of viewers was determined by the formula:

$$V = \nu N,$$

where, ν - specific volume, m^3;

N - number of viewers.

In accordance with KMK 2.01.08-19 "Protection against noise" [2]of the Republic of Uzbekistan for a multi-purpose hall, a specific volume is recommended that is 6 m^3/person.

Then so the air volume of this hall is:

$$V = \nu N = 6*800=4800 \text{ m}^3$$

Also, when choosing the parameters of the hall, we take into account the following aspects:

- Ratio of the length of the hall to its average width corresponds to the range 1-2 and does not exactly exceed 3. In our case: the length of the hall / average width of the hall = 28.43 / 16.5 = 1.73
- Ratio of the average width of the hall to its average height also lies in the range 1-2 and does not exceed 3. In our case: average hall width / average height of the hall= 16,5/7=2,36
- Length of the hall with the stage box is no more than 26 m from the back wall to the curtain. In our project length is 28.4 m.

The harmonious proportions of the hall can be determined by the size of its volume, using the module of the golden section of the linear dimensions of the hall. The golden ratio is a size ratio close to that of 3: 5: 8.

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The module of the golden section in our case is equal to:

X = 16.869 / 4.94 = 3.45

where, *v*-is the required volume of the hall, m^3.

Height H = 3.45 * 3 = 10.35; width B = 3.45 * 5 = 17.25; length L = 3.45 * 8 = 27.6.

Since the shape of the hall is not assumed to be rectangular in plan, these dimensions are only approximate or, in other words, average values according to these measurements.

The shape of the halls depends on their purpose however there are general requirements, the observance of which allows you to achieve good acoustics of the halls:

- The distance between the sound source and the listener should be minimal;
- The shape of the plan should take into account the directivity of the sound source. The angle between the rays directed from the source to the extreme rows of the parterre should be minimal;
- The shape of the reflective surfaces near the sound source should ensure the maximum possible transfer of sound energy to the last rows
- The radius of curvature of concave and vaulted surfaces with low sound absorption must exceed the distance from the source to the concave surface by at least 2 times, which will avoid foci of sound concentration;
- In halls of large capacity, parallelism of the walls, as well as the parallelism of the floor and ceiling, should be avoided to prevent the appearance of interference of reflected sound waves (the appearance of standing waves), leading to uneven distribution of sound. The deviation from the parallelism of the side walls by 2-3° eliminates such undesirable phenomena as "fluttering echo" and sound concentration [4].

The shape of the hall in the plan that meets the normative requirements is shown in Fig.1.

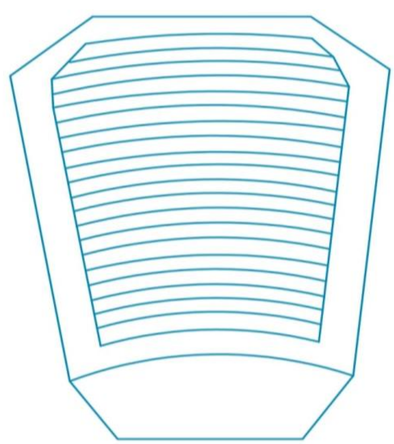

Fig.1. Choosing a rational form of the hall

If the last rows are more than 30 m away from the sound source, arrange a balcony.

The floor of the parterre and the balcony should have a profile that provides good visibility of the stage, which reduces the absorption of direct sound when it propagates from the source above the listeners (Fig. 2). The floor of the hall will rise by approximately 12 cm per row. Rows located at a distance of less than 9-10 m from the sound source do not require lifting. The balcony floor can be designed with a slightly higher rise h. The height of the proscenium is 1 m. The width of the spectator seat is 0.6 m. The distance between the rows (between the backs of the seats) is 2 m.

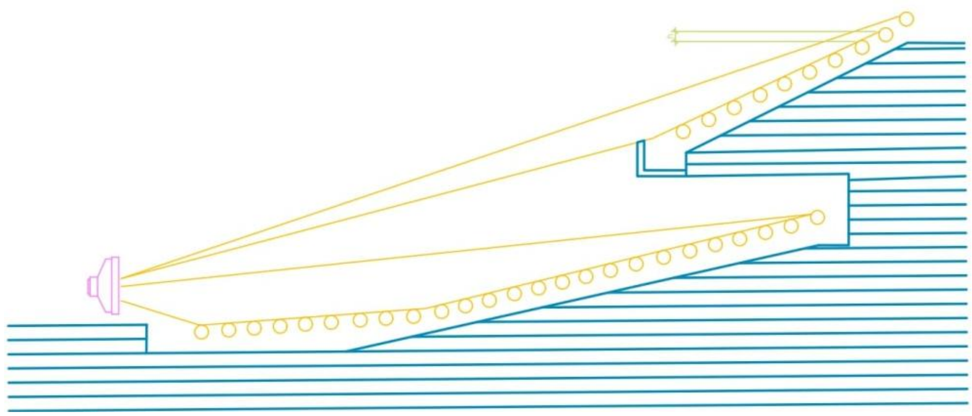

Fig. 2. Floor profile to provide direct sound to each seating position

To increase the sound pressure level of the useful sound, tilt the rear of the ceiling and rear wall as shown in Fig. 3.

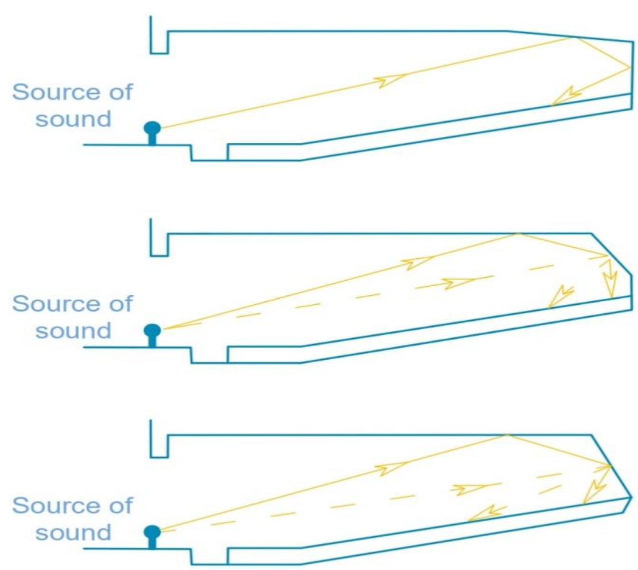

Fig. 3. Rational types of abutment of the ceiling to the rear wall

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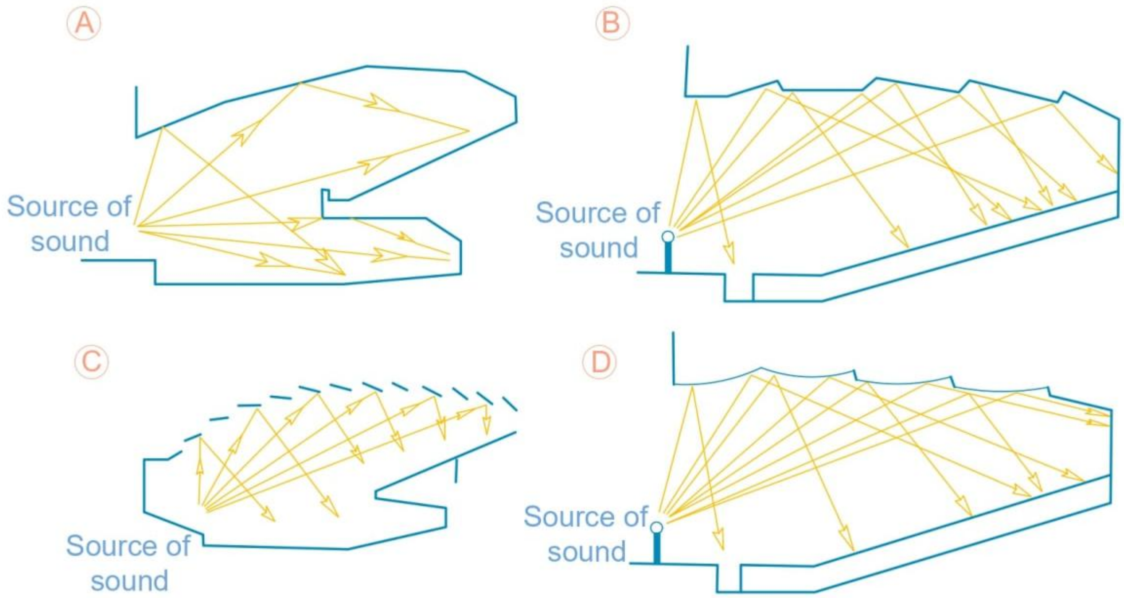

Fig. 4. Ceiling shape and profile to ensure adequate reflection

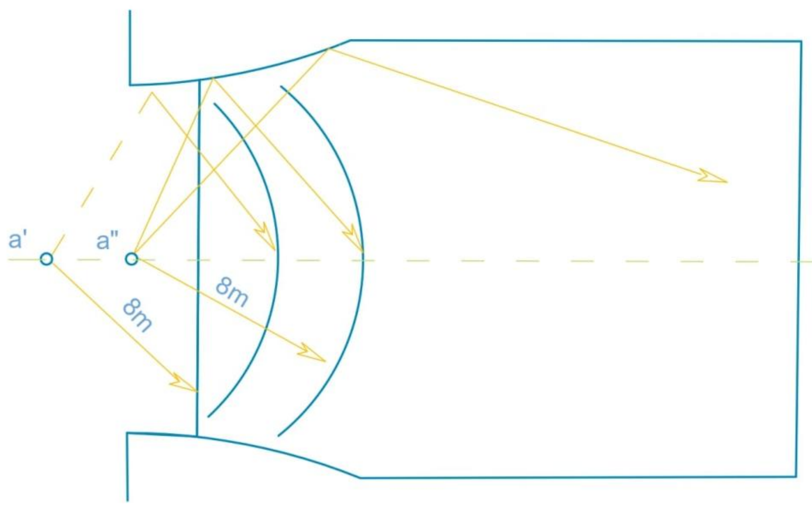

Fig. 5. Arrangement of reflectors on the side surfaces

In halls, acoustic conditions should be good enough for a wide variety of programs, although these conditions are often conflicting [5,6,7,8].

Relatively short reverberation time is provided in the hall, and its inner surfaces are formed in such a way that some of them send low-intensity low-range reflections to the listeners, increasing the clarity of the sound, while the other part creates a diffuse reflection of sound, which increases the diffuseness of the sound field. This is achieved by varying degrees of dismemberment of the individual surfaces of the hall.

As in music halls, early reflections are best received primarily from the side walls. This will

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enhance the spatial impression while increasing the clarity of the sound.

The most justified compromise solution for multipurpose halls of medium capacity (300-1200 seats)[9,10]. In our project we had 800 seats. In such halls, there is no particular need for long reverberation times. The maximum volume of the hall is 1500-6000 m^3. In our project we had 4932 m^3.

In large multi-purpose halls, the acoustic solution is associated with the use of electroacoustic. The hall provides the necessary reverberation time for speech programs. The extended reverberation time during the performance of concert programs is carried out with the help of artificial reverberation systems. The second approach to the acoustic solution of large halls is based on the use of variable sound absorption, as well as the transformation of sound-reflecting surfaces and the volume of the hall.

The halls should not have concave surfaces that have the property of concentrating the sound reflected by them. The concentration of sound with a small delay leads to a deterioration in speech intelligibility, and with a large delay, a strong echo appears. To prevent sound concentration, the radius of curvature of the wall or ceiling, R, must be twice the distance from the wall to the source.

Convex surfaces, on the contrary, create diffuse reflection of sound and increase the diffuseness of the sound field, therefore in this hall we have designed a convex profiling of the walls - pilasters D = 0.5m and located with a step of 3m.

Also, in this multipurpose hall, a balcony has been designed, which increases the diffuseness of the sound field at such low frequencies at which the pilasters do not provide sufficient dispersion.

In halls with a capacity of more than 600 listeners, it is advisable to arrange one or several balconies, which reduces the volume of the hall, reduces its length and increases the diffuseness of the field.

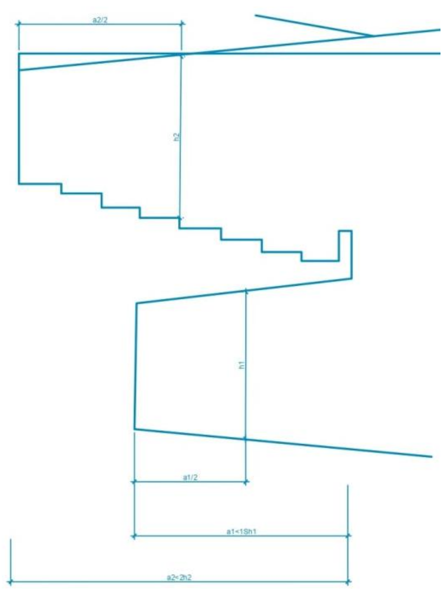

Fig. 6. Appropriate proportions of the balcony space

So, the main conditions that ensured the diffuseness of the sound field:

- No sharp differences in the basic dimensions of the hall
- Non-parallelism of walls, ceiling and floor.
- segmentation of a significant part of the internal surfaces.
- the presence of a balcony.

RESULTS

Calculations and solutions have shown that the acoustic properties of multipurpose hall with capacity of 800 people of this configuration meet the standards and requirements.

Checking the volume of the hall showed that the required specific volume per person is provided.

Along with the recommended reverberation time at 6 frequencies, a deviation from the recommended time in the range of 0.20-7.09% is provided.

According to the permissible delay time of the reflected sound, it satisfies the geometric constructions and is in the range of 0.02-0.03 s.

CONCLUSION

Consequently to prevent the concentration of reflected sound: there are no concave surfaces in the hall that have the properties of concentrating sound, the presence of a balcony and pilasters also contributes to the diffusion of the sound field.

By the formation of a diffuse sound field: a significant part of the interior surfaces of the hall due to non-parallelism creates a diffuse propagation of sound.

The presence of profiled floors, ceilings and walls also contributes to the dispersion of sound.

REFERENCES

1. Pirmatov, Rakhmatilla Khamidullaevich, and Jasur Gayrat Ugli Rashidov. "Research Of The Acoustic Parameters Of Halls And Practical Methods Of Eliminating Acoustic Defects." The American Journal of Engineering and Technology 2.12 (2020): 7-13.
2. Normative document of 2.01. 08-19 Noise protection, Tashkent, 2019[КМК 2.01. 08-19 “Защита от шума”.Ташкент,2019].
3. Pirmatov, R. K., Zakharov, A. V., & Rashidov, J. G. (2019). Graphical method for calculating sound insulation of air noise of single layer enclosing structures. International Journal of Advanced Research in Science, Engineering and Technology, 6(7), 10294-10298.
4. Pirmatov, R. Kh., & Rashidov, J. G. An integrated approach to the problem of fluttering echo and practical methods of eliminating acoustic defects in halls. Fundamental and applied research: topical, 71[Пирматов, Р. Х., & Рашидов, Ж. Г. Комплексный подход к проблеме возникновения порхающего эха и практические методы устранения акустических дефектов зальных помещений. Фундаментальные и прикладные научные исследования: актуальные, 71].
5. Jasur, Rashidov. "Modern methods of reduction of noise of enclosing structures in the Republic of Uzbekistan." https://scholar.google.com/scholar?oi=bib

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s&cluster=16100709863394381247&btnI=1&hl=ru

6. Gade, Anders C. "Acoustics in halls for speech and music." Springer handbook of acoustics. Springer, New York, NY, 2014. 317-366.
7. Beranek, Leo. Concert halls and opera houses: music, acoustics, and architecture. Springer Science & Business Media, 2012.
8. Cerdá, S., et al. "A factor analysis approach to determining a small number of parameters for characterising halls." Acta Acustica united with Acustica 97.3 (2011): 441-452.
9. Eggenschwiler, Kurt. "Lecture Halls-Room Acoustics and Sound Reinforcement." Forum Acusticum, Budapest. 2005.
10. Mehta, Madan, James Johnson, and Jorge Rocafort. Architectural acoustics: principles and design. 1999.