The influence of concert hall architecture on acoustics (the effect of musical performance)

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Abstract. The article analyzes the influence of the architecture of the concert hall on acoustics and the formation of the effect of musical performance. The author notes that the architecture of a concert hall can be of great importance in providing an acoustic effect. In addition, the acoustics of a concert hall can influence how musicians perceive their playing and how the audience perceives the work. Some factors that may affect the acoustics of a concert hall include the shape and size of the hall, the materials used to finish the walls and ceiling, the location of the stage and audience seats, as well as acoustic equipment. The shape of the concert hall affects how sound waves are reflected inside the hall. An ideal concert hall should have a shape that allows sound waves to spread evenly in all directions and reflect off the walls and ceiling in such a manner that a uniform sound background is created. This helps to create clarity and clarity of sound. At the present stage, special software tools are used to simulate sound in the hall, experiments are carried out with various acoustic materials and the arrangement of elements in the hall, and experienced architects who have deep knowledge in the field of acoustics and sound engineering are also involved.

1 Introduction

Concert halls are the centers of attraction for musical performers and music lovers all over the world. It is on the territory of such halls that famous and novice performers present their performing skills to the audience, for this reason, the importance of acoustics in such halls is beyond doubt [1].

The architecture of a concert hall can significantly affect its acoustics, that is, the sound produced by musicians on stage and heard by the audience in the hall. In addition, the acoustics of a concert hall can influence how musicians perceive their playing and how the audience perceives the work. Some factors that may affect the acoustics of a concert hall include the shape and size of the hall, the materials used to finish the walls and ceiling, the location of the stage and audience seats, as well as acoustic equipment [2].

Accordingly, a well-designed concert hall allows musicians to fully reveal their talent to the audience and convey to them their artistic idea embodied in music. On the other hand, the perception of music by listeners in a well-organized concert hall from the point of view

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of architectural features will allow them to understand the level of performing skills of musicians, as well as completely surrender to a piece of music and get true aesthetic pleasure.

The purpose of the work is to study the influence of the architecture of the concert hall on acoustics and the formation of the effect of musical performance.

2 Materials and methods

In the process of writing the work, an analysis of the array of special literature was carried out, comparative and analytical research methods were used in the preparation of the article.

3 Results

The shape of the concert hall plays an important role in the quality of acoustics. This is due to the fact that the sound waves that are produced on stage are reflected from the walls and ceiling of the hall, creating a so-called reverberation. Reverberation is the effect of sound reflection, which gives depth, volume and warmth to the sound. The choice of the architectural form of a concert hall depends on many factors, such as acoustic properties, visual aesthetics, accessibility, cost, etc.

The concert hall should also be visually attractive. The architectural form can be chosen taking into account the appearance of the building and its correspondence with the surrounding buildings. The aesthetics of the interior space of the hall is also important, including convenience and comfort for the audience.

The concert hall should be accessible to everyone, including people with disabilities. This may include choosing the shape of the hall, which provides easy access to places for the disabled and the provision of other appropriate services and facilities [3]. The choice of architectural form of a concert hall may also depend on cultural factors, such as local traditions and preferences in music and art. For example, halls for classical music may have a different shape than halls for rock concerts. These factors are usually taken into account in the design process of a concert hall in order to create a building that meets the needs and desires of listeners and provides the best possible sound and visual quality for speakers and spectators.

It is also important to take into account other factors, such as accessibility to the building, proximity to transport hubs, etc., in order to make the hall as convenient as possible for all visitors. When designing a concert hall, it is important to take into account all these factors in order to create a building that meets the needs of the community and is a place for high-quality cultural events [4].

The concert hall should have good acoustics so that the sound is evenly distributed and not distorted. Architects and engineers use various methods to achieve this goal, including the shape and size of the hall, the use of materials for sound insulation and the placement of sound-absorbing materials.

There are many concert halls around the world, each of which has its own architectural features and technologies that ensure high sound quality. Let's look at some examples.

1. Concert Hall of the Vienna Philharmonic (Vienna, Austria). One of the most famous concert halls in the world, built in 1870 and renovated in 2004, has acoustic properties considered to be among the best in the world. The hall uses the classic "box" form, which provides a high level of sound reflection from the walls and ceiling, and also allows you to distribute sound waves evenly in the hall. The main materials used in the construction of the hall are wood and silk, which have a high sound absorption coefficient. 2. Sydney Concert Hall (Sydney, Australia)
2. Built in 1973, the Sydney Concert Hall has a unique architecture, which is a large round hall surrounded by a ring of steps for the audience. Various materials such as wood, concrete and glass are used in the hall, which provides a high level of sound absorption and reflection.

3. Concertgebouw Hall (Amsterdam, Netherlands). The Concertgebouw Concert Hall has the shape of a cube and was built in 1888. It was renovated in 1988 using new technologies and materials such as aluminum and concrete. The hall uses a system of suspended panels, which allows one to adjust the reflection and absorption of sound depending on the concert and the desire of the sound engineer. There is also a mechanical platform in the hall, which makes it possible to change the shape of the hall depending on the event and the mood of the audience.

4. Carnegie Hall (New York, USA). Carnegie Hall was built in 1891 and is one of the most famous concert halls in the world. It was designed with high acoustic requirements in mind and is a rectangular hall with high ceilings and lots of wooden finishes. One of the key elements of the acoustics of the hall is a special system of suspended panels, which can adjust the reflection and absorption of sound depending on the concert and the desire of the sound engineer. This system consists of more than 6,000 suspended panels that can be raised or lowered depending on the need. Carnegie Hall also has a sophisticated ventilation and air conditioning system that helps maintain optimal conditions for acoustics and audience comfort.

Despite the fact that Carnegie Hall was built more than a hundred years ago, it continues to be one of the most important concert halls in the world. Many famous musicians have performed here, including Tchaikovsky, Rachmaninov, Shostakovich, Lenny Bernstein and many others.

All of the above concert halls, like many others, are designed in such a way as to achieve the effect of musical performance. The effect of musical performance in a concert hall is a phenomenon when live performance of music in a concert hall causes emotional and physical effects in listeners, leading to strong feelings and experiences [5]. This effect can be associated with many factors, such as the musical skills of the performers, the sound quality and acoustics of the hall, as well as the atmosphere created by the audience and the performers themselves.

When a piece of music is performed by live musicians, listeners can feel a deeper interaction with the music and the performers. They can hear not only sounds, but also the soul that is embedded in music. In a concert hall, the audience often feels closer to the piece, and the emotional impact of the music can be more intense [6].

Also, the sound quality and acoustics of the hall can also affect the effect of musical performance. A well-sounding hall can help music convey more vivid emotional nuances and create a more complete sound space. On the other hand, a bad-sounding hall can reduce the sound quality and make it difficult to perceive music. Finally, the effect of musical performance in a concert hall can be influenced by the atmosphere created by the audience and the performers themselves [7]. If the hall is filled with people who expect and appreciate high-quality performance, then this can create a more favorable atmosphere for the effect of musical performance.

In general, the effect of musical performance in a concert hall is a complex phenomenon associated with many factors. It can create strong emotional and physical experiences in listeners and is one of the main reasons why live performances of musicians continue to be popular in our time [8].

The shortcomings of the architectural design of concert halls can negatively affect the sound quality of the audience and their perception of music in general. For example, the project of the Bayreuth Festival Opera House has several drawbacks. For example, the opera house building was specially designed for the Richard Wagner Opera Festival, which limits its use for other purposes and at other times of the year. Problems with acoustics were found
in the opera house building, which means that the sound in the hall does not always sound good, especially for orchestral instruments [9].

The design of the orchestra pit in this theater also has its drawbacks: it is deep enough that it does not allow the viewer to see the work of the conductor, and also negatively affects the contact of artists and performers performing on stage with musicians. The considered arrangement of the orchestra pit negates the localization of not only individual instruments, but also the entire orchestra, is practically impossible. But if an optimal balance was formed in the hall between the vocalists and the orchestra, then the performers themselves had to adapt to new acoustic features. Due to the long reverberation time, communication between the orchestra and vocalists was difficult (which could affect the compatibility of the performance). The arrangement of the orchestra also differed from the generally accepted one: the first violins were to the right of the conductor. Double basses, cellos and harps were divided into groups and placed on both sides of the pit.

Due to the fact that the reflected sound mainly came into the hall from the orchestra, the timbre changed when the curtain was closed (the sound of the overture) and open. Overlays and comb filter effects could create distortions affecting the typical timbre of an individual instrument. For example, some experts noted the similarity of the sound of double basses and timpani. It was also noticed that in a half-empty hall, the acoustics deteriorate sharply, in particular, a fluttering echo appears [10].

Accordingly, the architectural design of the concert hall directly affects its acoustic capabilities, as well as the rating in the performing environment, since performing at a venue whose acoustics allow the audience to fully present the beauty and completeness of a musical work, performers have the opportunity to realize themselves as true masters of the musical word.

4 Discussion

Providing the necessary acoustics in a concert hall is an important aspect of architectural technologies that can affect the effect of musical performance. Figure 1 shows some of the technologies used to provide high-quality acoustics.

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**Fig. 1.** Technologies used to ensure high-quality acoustics in a concert hall.
Let's consider these technologies in more detail.

1. Acoustic handling: to achieve the necessary acoustics of the concert hall, special materials and structures that absorb, reflect or disperse sound can be used. For example, to reduce the effect of sound reflection, you can use acoustic panels that are installed on the walls and ceiling of the hall. They can be made of various materials, such as porous materials, textiles, wood and others. Also, to improve the acoustics of the hall, diffusers can be used that reflect sound in different directions, which creates a more natural sound space [11].

2. Design features: the design features of the hall can also affect the acoustics. For example, the shape and size of a hall can determine how sound propagates and is reflected inside it. The optimal shape of a concert hall is usually rounded or elliptical. In addition, it is important to take into account the height of the ceiling and the distance between the walls in order to achieve an optimal sound space.

3. Sound system: the sound system used in the concert hall also plays an important role in providing the necessary acoustics. The system should be designed in such a way as to ensure uniform sound distribution throughout the hall. For this purpose, various types of speakers and devices can be used, such as sound diffusers, etc.

4. Location of the stage and auditorium: the location of the stage and auditorium is also important to ensure good acoustics. The stage should be positioned in such a way that the sound can spread freely and without interference. The auditorium should be designed in such a way that every spectator has the opportunity to hear the sound clearly and clearly [12].

Thus, providing the necessary acoustics of a concert hall requires an integrated approach, including the use of various architectural technologies and technical devices. It is important to take into account both the design features of the hall and the acoustic treatment in order to create ideal conditions for effective musical performance and getting the maximum effect from it. It is necessary to take into account another important aspect of the acoustics of a concert hall - this is sound scattering. Unlike direct sound, which is directed directly at the listener, diffuse sound is reflected from the walls and ceiling of the hall, creating a pleasant and natural sound. To achieve this effect, special materials and surfaces are used that disperse sound, as well as computer simulations that help optimize the location of sound scattering elements in the hall.

Finally, an important factor in the acoustics of a concert hall is sound insulation. In order to prevent the penetration of external noise into the hall and maintain high sound quality, it is necessary to provide good insulation. For this purpose, special materials and structures are used, such as double walls, thickened floors and ceilings, as well as special seals for doors and windows [13].

In general, creating the perfect acoustics of a concert hall is a complex and multifaceted process that requires deep knowledge in the field of architecture, sound physics and engineering technologies. However, a properly designed and equipped concert hall can create an unforgettable experience for listeners and give them unforgettable musical emotions.

Computer technologies play an important role in the architectural design of concert halls with certain acoustic features. For example, computer models can be used to accurately calculate the acoustic parameters of the hall, such as sound pressure, reverberation time, etc. These parameters can be determined based on the physical characteristics of the building, such as size, shape, materials and the location of acoustic elements such as walls, ceiling, floor and sound-absorbing materials.

In addition, computer technology allows you to simulate the sound field inside the hall, which allows architects and sound engineers to assess how the sound will sound in different places of the hall and how it will be perceived by listeners at different points. This allows you to improve the acoustic characteristics of the hall and achieve the best sound quality.
There are special programs and tools for modeling the acoustic parameters of the hall, such as Odeon, EASE, CATT-Acoustic, which allow you to design halls of various types, from small concert venues to large opera houses.

Computer technology is also used to develop and install sound systems in concert halls. With their help, you can select and optimize sound equipment, develop settings and control sound in real time [14].

There are programs for sound control in halls, such as Smaart, which can measure and analyze sound parameters in the hall, such as sound pressure level, delay and equalizer. This data can be used to optimize the sound system and improve the sound quality [15].

5 Conclusion

The architecture of the concert hall has its own characteristics, which are initially fixed through its shape. The shape of the concert hall affects how sound waves are reflected inside the hall. An ideal concert hall should have a shape that allows sound waves to spread evenly in all directions and reflect off the walls and ceiling in such a manner that a uniform sound background is created. This helps to create clarity of sound, which is important for an opera house, where words and music should be clearly heard.

However, the shape of the hall is not the only factor that affects the quality of acoustics. Also important are the size of the hall, the materials from which the walls, ceiling and floor are made, as well as the location of the stage and acoustic elements in the hall, such as sound-absorbing and sound-scattering panels.

In addition, it is important to take into account the number of people who will attend the concert, as they also affect the sound atmosphere of the hall. The more people there are, the more sound will be reflected from bodies and clothes, and this can lead to the effect of "sound veiling", when the sound becomes less clear and legible, therefore, when designing a concert hall, many factors must be taken into account in order to achieve an optimal acoustic environment for various types of music and events. This may require the use of special software tools for modeling sound in the hall, conducting experiments with various acoustic materials and the arrangement of elements in the hall, as well as an experienced designer who has deep knowledge in the field of acoustics and sound engineering.

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