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Stravinsky Hall of the Moscow Musical Theatre "Helikon-Opera": acoustic challenges and achieved results

Dmitry Bertman[a], Nikolay Kanev[b], Anatoly Livshits[b]

[a] Moscow Musical Theatre "Helikon-Opera", Russia
[b] Acoustic Group, Russia, anatoly.livshits@acoustic.ru

Abstract

The musical theatre Helikon-Opera was founded in Moscow 26 years ago. Today the theatre is extremely popular not only in Russia, but even abroad. In 2007 a unique reconstruction of some historical buildings in the centre of Moscow started. Main challenge of this project was an adjustment of the courtyard for the opera hall equipped with the latest theatrical facilities. From acoustic point of view proposed concept had some difficulties. First of all the hall width is significantly over its length. Secondly it is the hall's huge volume, which is about 7000 cubic meters. At the same time it is designed for 500 seats only. Moreover, historical view of the courtyard walls should be entirely saved. So acoustic design was highly constrained but some improvements of its acoustic properties were realized. In this paper we present detailed description of the hall design and its acoustic features. Proposed changes in hall design based on the simulations and their influence on hall acoustics are given as well. After completion of the reconstruction acoustic parameters of the hall, stage and orchestra pit were measured. The most interesting result is relatively long reverberation time and good speech intelligibility. We discuss characteristics of the hall and compare it with other opera houses. On November 2, 2015 new hall for opera performances named Stravinsky Hall was officially opened. During several months after opening different subjective evaluations from soloists, musicians, conductors and spectators were collected. They are cited in the paper as well.

Keywords: opera house, room acoustics

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1 Introduction

What is "Helikon"? Some people think it is a mountain in ancient Greece, where singers and musicians die for the sake of Apollo and muses. The others are convinced that Helikon is nothing else but a massive wind instrument. But in Russia for a quarter of a century this word has been associated with a musical theatre founded in Moscow on April 10, 1990, which united the new talents. The theatre company of Helikon-Opera founded by Dmitry Bertman initially consisted of seven enthusiasts and counts more than 500 people nowadays. Every season Helikon-Opera presents to Moscow audience more than 200 performances and each of them gives the audience the joy of contact with live art. Helikon-Opera always tries to withdraw from "convenient", worn out stage impersonations to surprise with novelty and audacity of conception, bright vocal and dramatic performance, taking care of the composer's idea at the same time. This is one of the most interesting and visited theatres of the Russian capital.

Helikon-Opera is located on the territory of the oldest Moscow estate in the mansion of the Shakhovskoy-Glebov-Streshnev families. The mansion has the notable history of theatre and musical activities from 1743. A parade White Column Hall was constructed there to hold various vocal, musical, theatre performances and different meetings. The mansion remained a bright culture centre of Moscow until the beginning of 20th century. During Soviet period there was situated a society of medical workers in it. In 1990 a new chapter began in the glorious history of the building, where the walls remember S. Rachmaninoff, C. Debussy and F. Chaliapin. The mansion became the home for the Moscow Musical Theatre Helikon-Opera.

From 2007 to 2015 the theatre was under restoration and reconstruction. A unique renewal project with the adjustments for the theatrical needs was developed by a group of Russian architects. In accordance with the project there are two halls for 200 and 500 seats. Smaller hall is renovated as the White Column Hall, bigger one is a new hall built inside the former courtyard. Main challenge of this project was an adjustment of unsuitable space to a modern opera house. On November 2, 2015 new hall for opera performances named Stravinsky Hall was officially opened.

2 Acoustic solution of a new hall

There were several halls in the Shakhovskoy-Glebov-Streshnev mansion, the biggest of them was the While Column Hall with 200 seats. Growing theatre required more capacious house, but the building had great historical value. So it was not possible to destroy some constructions in order to build new hall inside the building. There was the courtyard enclosed by two and three-storied buildings. All facades were designed in beautiful Russian style with the main entrance in the form of a porch. Left photographs in Figure 1 and 2 demonstrate parts of the courtyard with the porch and the facade before reconstruction.

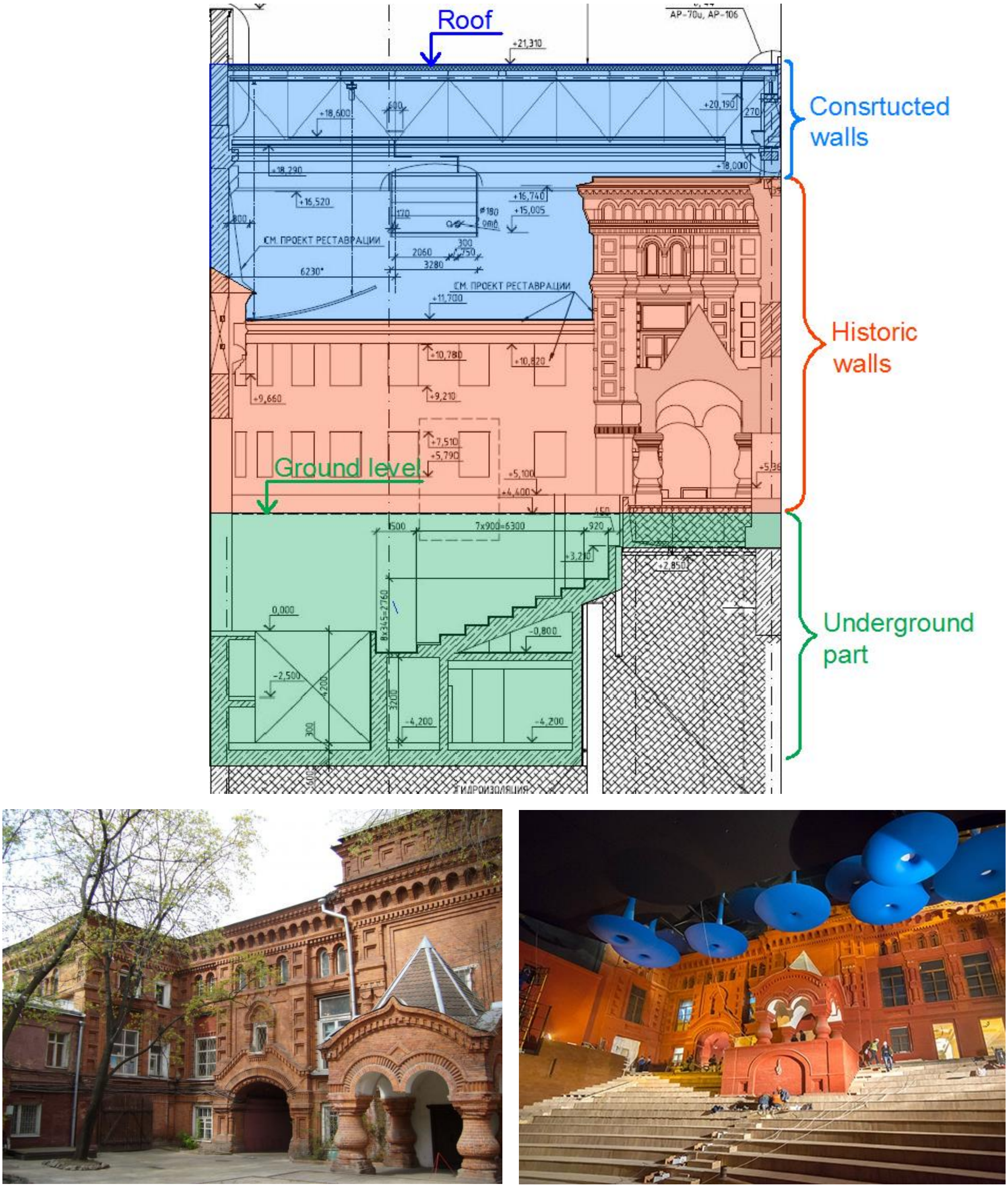

Figure 1: Stravinsky Hall construction. The courtyard before reconstruction (left photograph) and the new hall during construction works (right photograph)

It was decided to adjust this place to a new opera house. But there were some limitations due to historic value of the building. First of them consisted in preservation of the existing facades, the porch and the architectural elements. Moreover, all of them should be visible, which made construction of balconies impossible. Second limit concerned the height of a new roof over the courtyard. New buildings could not be higher than existing ones, so the stage level should have been as low as possible in order to save height of the stage box. For this purpose the stage and seating rows were constructed below ground level marked on the scheme and shown on the left photograph in Figure 1. The depth of the underground part of the building is about 10 meters. The roof level had to be the same with other building, for this purpose the new walls marked by blue color in Figure 1 were constructed. It resulted in very high enclosure (the maximal height is approx. 19 m) for the opera house.

The shape of the courtyard was close to rectangular with the length of about 21 m and the width of about 31 m (see plan in Figure 3). From acoustical point of view such geometry coupled with huge height is not appropriate for opera houses. Thus the greatest challenge of this project was to adapt this space for good acoustics.

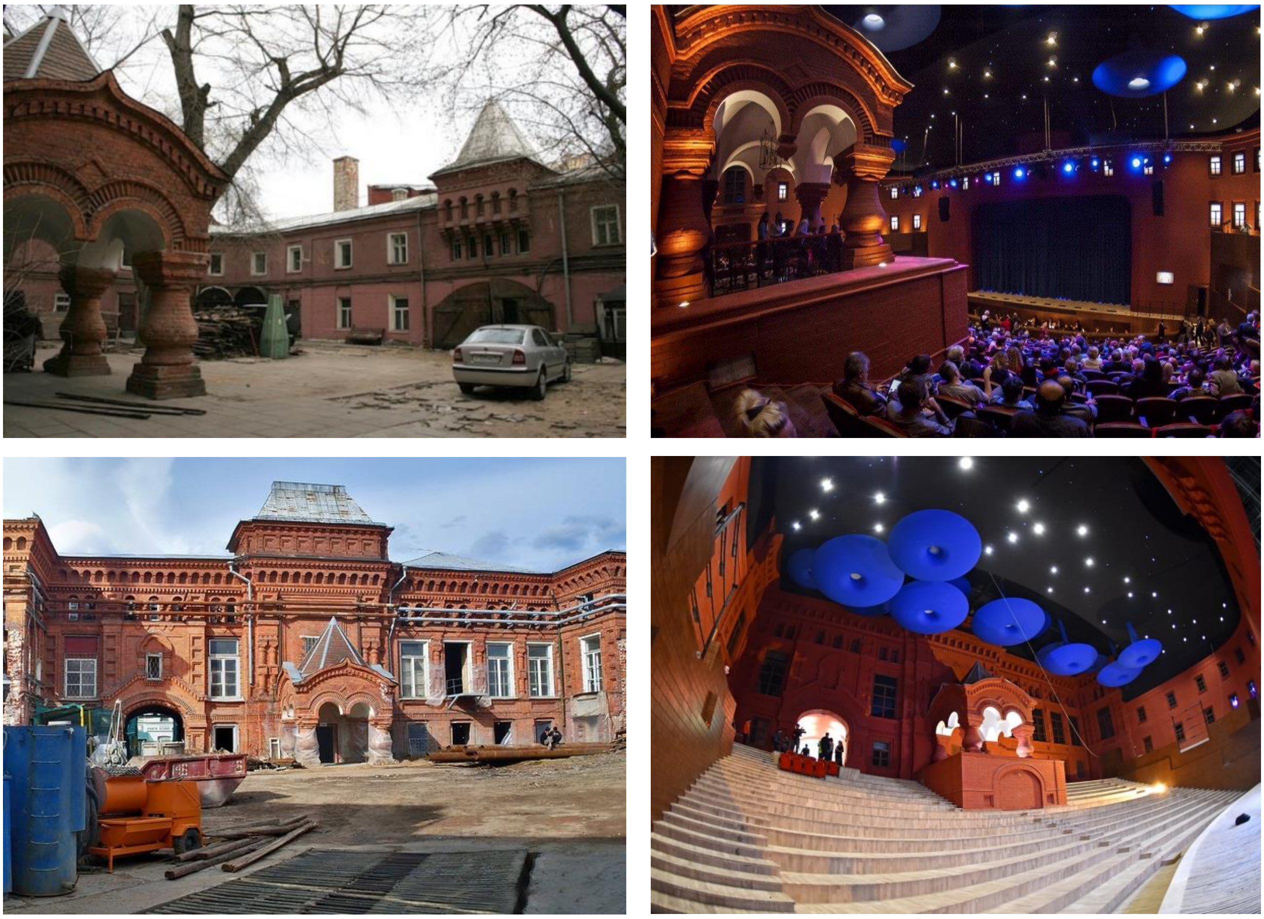

Figure 2: Photographs of the courtyard and the hall from similar views – from the back wall to the stage (upper photographs) and inverse view (below photographs)

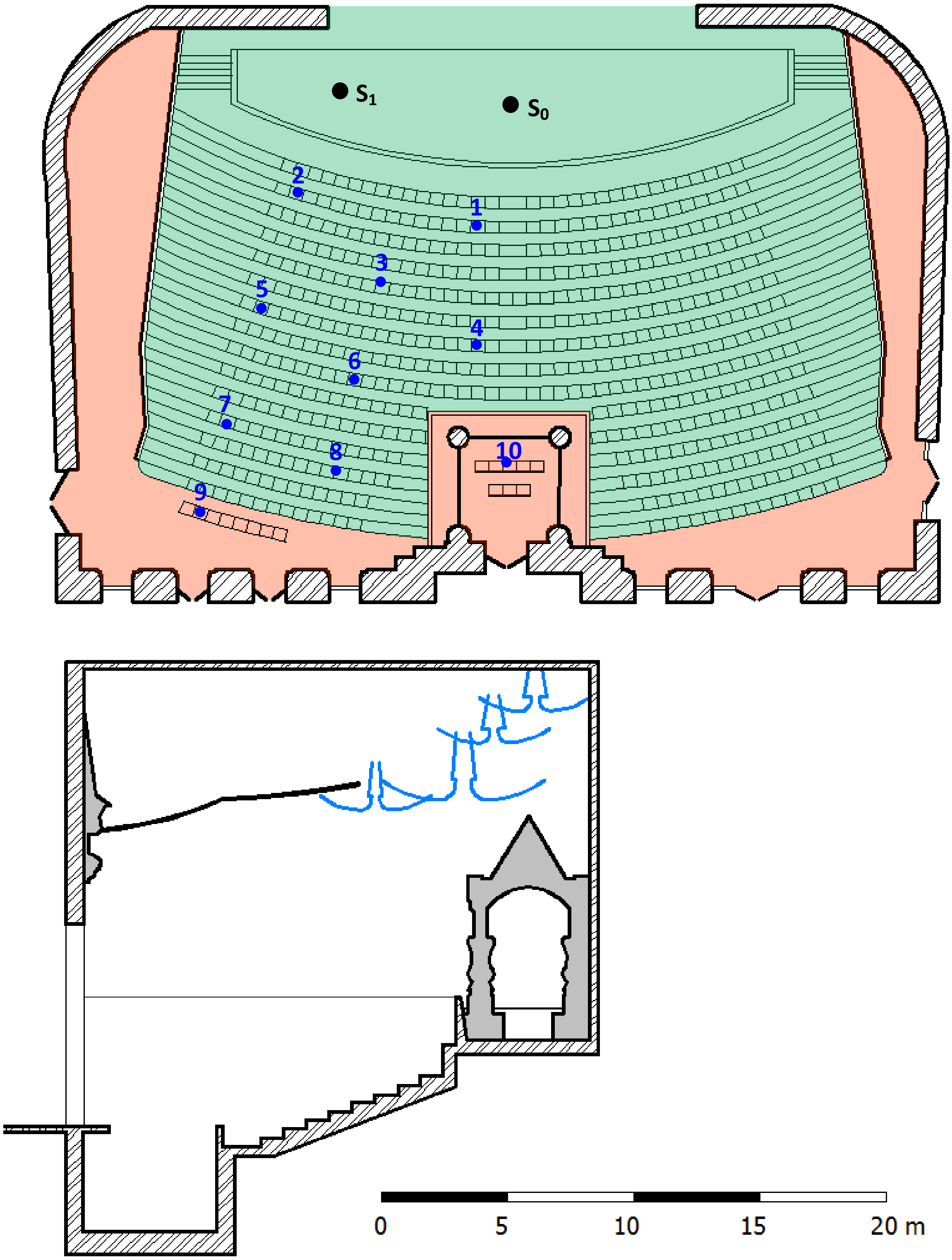

Figure 3: Plan and central section of the hall. Initial level of the courtyard is marked by red color

Preliminary acoustic solution of the hall was developed in 2005 [1]. Then some modifications were implemented and final corrections took place until the finishing of construction works. Final solution of the hall is presented in Figures 1-3.

Because of wide width of the courtyard the deepening of the hall was realized only in the middle part marked by green colour in Figure 3. Initial level of the courtyard is shown by red colour. So effective width of the audience area is about 25 m instead of 31 m and the side walls are able to provide more lateral sound reflections. These walls are made of thick wooden panels with low absorption coefficient.

In order to reduce the height the gypsum canopy of 60 mm thick is installed. Its form is adjusted to direct sound from the stage toward the audience, but its length is limited by the requirement of visibility of the rear wall.

In the back part of the hall there are eleven diffusive elements named helikons like upturned umbrellas (blue elements in Figures 1 and 2). They have different sizes and reduce the effective volume of the hall. Furthermore, their height may be mechanically regulated, so the hall volume can be slightly varied. But this variation does not lead to notable changes of hall acoustics. Note that similar reflectors were suspended in Royal Albert Hall to suppress the echo problem [3].

The floor is made by traditional technology. The solid pine boards with the oak parquet lie on the pine bearing with 70 mm air gap between the concrete floor and the boards. Such kind of the floor supports vibrations generated by music that reach the feet of the audience. It effects positively on the overall emotional perception of musical performance [2].

3 Objective measurements

3.1 Measurement procedure

After the finishing of the construction works acoustic parameters of the Stravinsky Hall were measured. The measurements were executed in accordance with ISO 3382 without audiences and any decoration on the stage, with fire and performing curtains open. A dodecahedral loudspeaker was placed in two points in the orchestra pit. When the pit floor was lifted up to the level of the stage the places of the sound source were the same. Impulse responses were recorded in 10 points shown in Figure 3.

3.2 Acoustic parameters

3.2.1 Reverberation time and early decay time

Frequency dependence of measured reverberation time is presented in Figure 4. Its values are more than 2.5 s at middle frequencies, but calculated reverberation time in the hall with audience is significantly smaller. RT_{mid} is 2.0 s, BR is 1.19. It is important that EDT is smaller than RT at all frequencies. The difference is about 0.2-0.5 s, which means that subjectively reverberation is shorter than 2 s. Such RT and EDT are typical for the opera houses with much greater volume [3,4]. Note that RT and EDT measured with the sound source in the orchestra pit and with the sound source on the stage are very close. Deviation of measured parameters for different displacement of the source is within 5% at all frequencies.

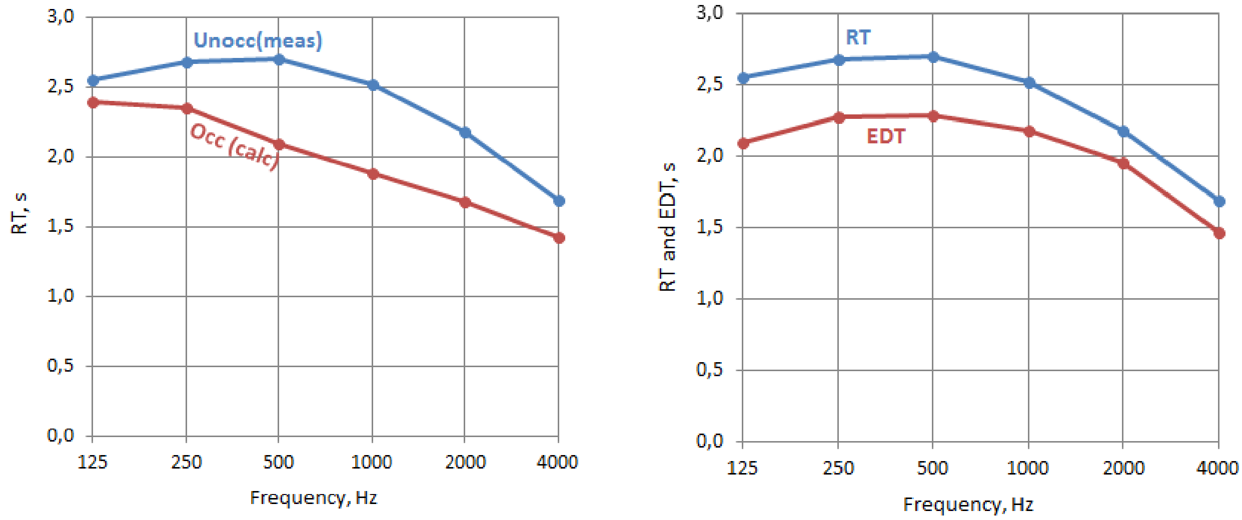

Figure 4: Reverberation time measured in the unoccupied hall (blue lines) in comparison with calculated one for the occupied hall (left) and measured early decay time (right)

3.2.2 Clarity C_{80}

The sound from the orchestra pit is of primary importance, but some performances are going to be with the orchestra on the proscenium when the pit floor is lifted up. Average clarity for two locations of the source is presented in Figure 5. Difference of C_{80} is from 1.5 to 3.1 dB for different frequencies. The average value $C_{80,3}$ over 500, 1000 and 2000 Hz is 0.9 dB with the sound source on the stage and -1.4 dB with the sound source in the orchestra pit. In contrast to RT and EDT clarity differs significantly with the change of sound source location.

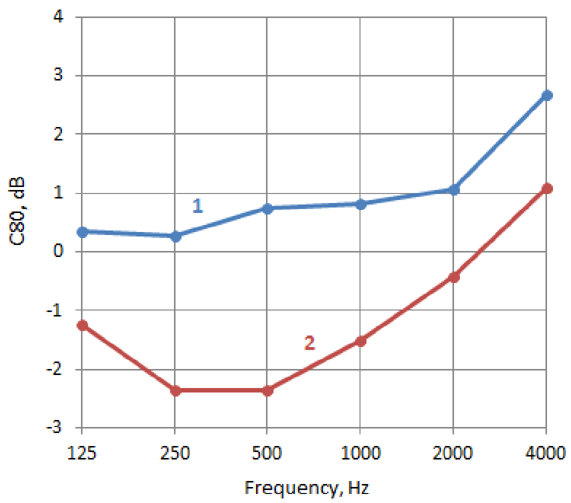

Figure 5: Clarity C80 with the sound source on the stage (1) and in the orchestra pit (2)

3.2.3 Stage and orchestra pit support

For characterizing acoustics support parameters ST_{early} and ST_{total} are used. These parameters are measured in the orchestra pit and on the stage (Figure 6). Due to reflection from the pit walls both parameters in the pit are greater by 5-10 dB then on the stage. According to [3] a desirable range of ST_{early} concert halls is from -14.4 to -12 dB. ST_{early} measured on the stage is within the desirable range at middle frequencies. So comfortable conditions for concerts with the orchestra on the stage are expected. But musicians may find the pit is too loud. In this case absorbing materials can be applied at the back wall of the orchestra pit.

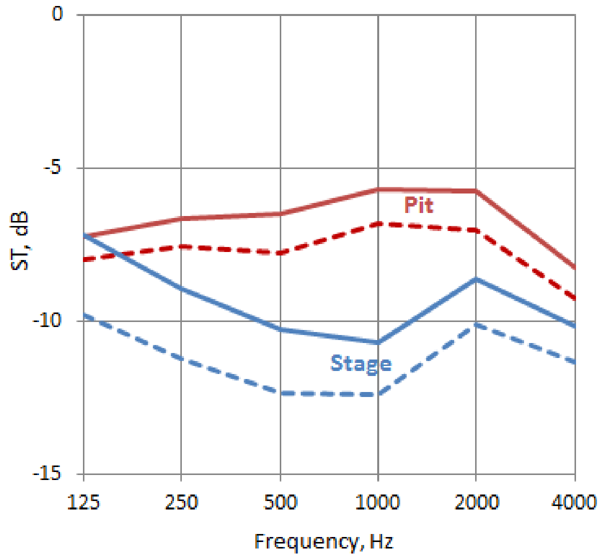

Figure 6: Early (dotted lines) and total (solid lines) support with the sound source on the stage and in the orchestra pit

3.2.4 Reflectograms

Analysis of reflectograms provides to obtain an initial-time-delay gap and to estimate a number of significant reflections peaks. The initial-time-delay gap is usually measured near the center of the main floor [4]. In our case this position is 4 (Figure 3). Figure 7 contains two reflectograms measured with the source at position S_0 on the stage and in the orchestra pit. Signal amplitude on reflectograms is normalized by its maximal value during all impulse response.

If the source is on the stage then the most intensive reflection marked by a red arrow is from the canopy. Time delay with respect to direct sound is 42 ms. Between these peaks there are some weaker reflections, which are probably directed by the back wall. Note that the back wall is a part of the porch, in this reason it is close to the position 4. If we take into account maximal peak after direct sound, ITDG is 42 ms. This value is much greater then recommended for opera houses.

When the source is in the pit there are many strong peaks between direct sound and reflection from the canopy. But direct sound is reduced due to diffraction on the pit walls, so the reflection from the canopy is maximal peak on the reflectogram.

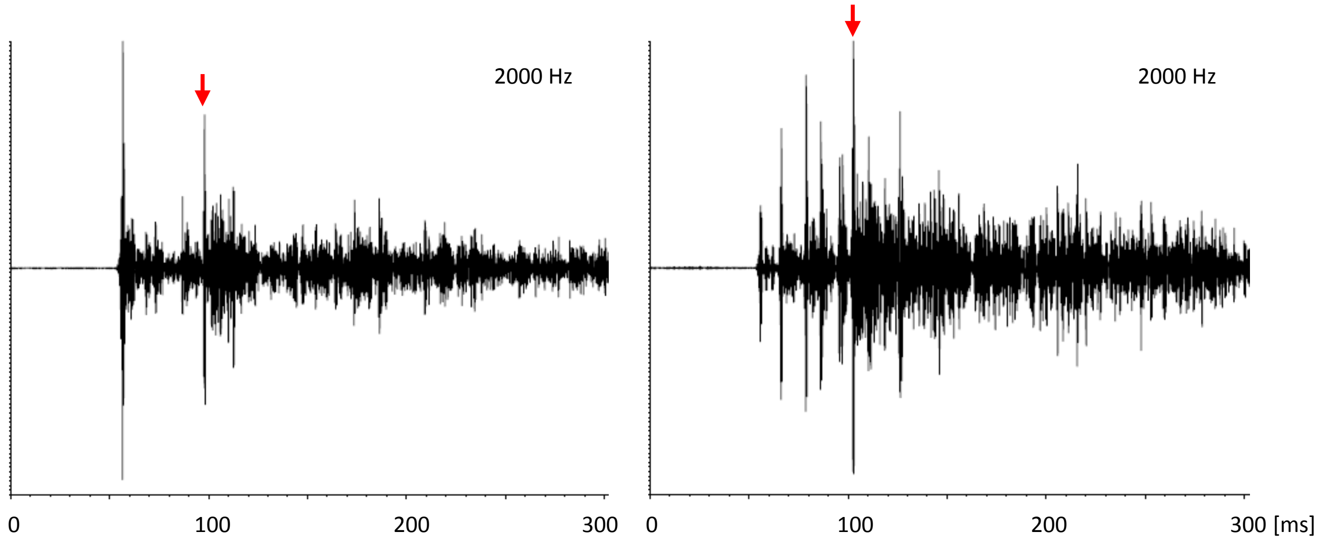

Figure 7: Reflectograms at microphone position 4 and source at position S_0 on the stage (left) and in the pit (right). Red arrows denote reflection from the canopy

4 Acoustic evaluation of the Stravinsky Hall

4.1 Subjective opinions

Subjective acoustical quality of the Stravinsky Hall has not been investigated yet. But we collected some comments from world-class artists and visitors, some of them are given bellow.

Vladimir Fedoseyev (Principal conductor of the State Academic Tchaikovsky Symphony Orchestra): “I have received very great impressions from singers and from the orchestra! The theatre has acquired this stunning hall where voices sound wonderfully”.

Placido Domingo (Spanish tenor): “This is an amazing achievement; one more impressive theater is in the number of first class theatres of Russia. This amazing hall has acoustics that equals to the best opera houses of the world”.

Dmitry Hvorostovsky (Russian baritone): “The most cherished dreams of a singer are brought to life In the Stravinsky hall! I have never heard such an accomplished opera sound anywhere in the world”.

Maria Maksakova (opera singer, Mariinsky Theatre): “As a singer I am glad that such excellent acoustics was achieved in the Stravinsky hall. Probably it is the best one in Moscow for one”.

4.2 Comparison with other opera houses

Here we compare acoustic parameter of the Stravinsky Hall with recommended one [3]. Reverberation time in occupied hall is equal 2.0 s, recommended range is 1.4-1.6 s for opera houses with more than 1200 seats. The hall is more reverberant in comparison with many houses, but there are some examples with similar RT.

Early decay time in unoccupied houses should be from 1.5 to 1.9 s, measured one is 2.2 s. EDT is closer to recommendation than RT. Only one opera house reviewed in [4] has greater EDT. So we can conclude the Stravinsky Hall is more reverberant than typical opera house.

Clarity parameter $C_{80,3}$ is 0.9 dB with the sound source on the stage, preferred values of this parameters are from -1.0 to 2.0 dB. $C_{80,3}$ is in the middle of the preferred range. When the sound source is in the orchestra pit $C_{80,3}$ is equal -1.4 dB. For such location of the source this parameter measured in 13 opera ranges from -2.6 to 0.3 dB. In this case $C_{80,3}$ is in the middle of the typical range as well.

Acoustic conditions on the stage seem to be good for the orchestra. At least the stage support factor coincides with recommended one for concert halls. Good support is provided mainly by the canopy over the stage.

5 Conclusions

The Moscow Musical Theatre “Helikon-Opera” gained new opera house with 500 seats. There were many limits on the acoustic design caused by requirements for the preservation of the existing architectural environment. Productive cooperation of architects, acoustic consultants and builders managed to find optimal solution of the hall and implement this complex and ambitious project. Its design combines a contemporary concept with a spirit of Moscow of the nineteenth century. New hall was named in honour of great Russian composer Igor Stravinsky.

Acoustic parameters of new opera house are close to recommended ones by [3,4], but some of them differs significantly. Reverberation time at middle frequencies is about 2 second while the hall volume is only 7000 cubic meters. Good acoustic conditions for the audience are provided mainly by early strong reflections from the canopy and the side walls. Furthermore, all seats are close to the stage in comparison with the traditional opera houses.

First evaluations from conductors, musicians, soloists and music critics during half a year of service allow expecting the true success of that venue for opera. Although, only time will reveal genuine acoustic rating among Russian opera houses.

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