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Acoustics of new and renovated chamber music halls in Russia

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In recent years several classic halls for chamber music were renovated and a few halls of similar capacity were built in Russia. The most interesting halls were selected for this investigation. Here are presented detailed descriptions of five halls in Moscow, Tula, Ufa and Penza in combination with the measurement data. Some of them have long reverberation time and their acoustics is considered as very good. There is an organ in two of the halls and another hall will be supplied with a new organ. Moreover, the hall in Ufa is destined not only for chamber music; amplified performances may also take place there. In spite of big differences between these halls the authors are trying to find connecting features and compare them with well-known chamber music halls. One of the main results is that we revealed the trend that general audience has subjective preferences towards longer reverberation time. Those results were obtained at the same time as evaluation of acoustic changes in the Bolshoi Theatre Historic stage and the Great Hall of the Moscow Conservatory due to reconstruction. Measurements of reverberation time in occupied and unoccupied hall were carried out, the results were compared with calculated values.

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1. INTRODUCTION

Over the last several years many small concert halls have been renovated or built in Russia. In this paper we consider the hall as small if it has no more than 500 seats. Some of the small halls are intended only for chamber music, some are multipurpose but they are regularly used for chamber music concerts as well. Acoustics of new or renovated symphony halls and opera houses are usually well described [1,2], whereas there are limited data about small music halls. Detailed analysis of chamber-music halls in Europe and Japan with their acoustical data was given by Hidaka and Nishihara [3]. In order to evaluate chamber-music halls in Russia several halls were selected and the room acoustical parameters were measured in each of the hall selected.

2. HALLS DESCRIPTION

Five concert halls in different Russian cities were examined. They have their own unique history and architecture, here is represented the brief description of them. Schemes and pictures of considered halls are given in Figures 1-5.

Two halls belong to the Tchaikovsky Moscow State Conservatory founded in 1866 by Nikolay Rubinstein. There are three concert halls in the Moscow Conservatory, the most famous of them is the Great Hall. Its acoustic parameters were measured several times and some results were published [4], so acoustics of the Great Hall seems to be well known. But acoustics of other halls is not studied so carefully.

First of them is Maliy (Small) Hall with 436 seats which was opened in 1898. There is an organ manufactured by Alexander Schuke Orgelbau installed in 1959. In the opinion of music lovers the hall has an ideal acoustics especially for chamber music. Different competitions and festivals including the International Tchaikovsky Competition take place here every year. In 2015 the Maliy Hall was renovated. Changes of its acoustics after renovation are briefly described below.

The oldest concert hall of the Moscow Conservatory is Rachmaninov Hall. It was built in 1890 for the Moscow Synodal School. In 1968 the hall was affiliated to the Moscow Conservatory and reopened in 1983 after long renovation. There is a balcony without seats along all walls, all seats are in the main floor. The hall is a stunning building due to its beautiful multiple windows and elegant decoration of the ceiling and walls. A lot of chamber and choir concerts are held in it almost every day, classical and modern music concerts are also performed occasionally here. In 2016 the Rachmaninov hall was renovated. Its acoustic parameters before the renovation have been measured and are presented below.

Another hall with a long history is the Column Hall of the Tula Philharmonic, which was built in 1856 as a part of the House for Assembly of Nobles. The hall has rectangular shape with a balcony along all the walls. There are many windows on side walls, so the day light comes inside. The distinguishing feature of the hall is a set of columns along the balcony, which defined his name. The seats are usually installed between the columns in the main floor as shown in Figure 3 in a number of about 300. It is possible to increase capacity by means of additional chairs behind the columns and on the balcony, but these seats have a poor visibility of the stage. Maximal capacity of the hall is about 500 seats.

In 2013 the construction work of a new house for the Penza Philharmonic was finished. The building has two halls, one of them is designed for chamber music and equipped with an organ

by Hugo Mayer. The shape of the hall is close to rectangular, but one wall is curved. Moreover, this wall is totally made of glass. The organ occupies the entire area of the front wall, there are two narrow balconies on the rear wall.

The Maliy Hall of the music house “Bashkortostan” in Ufa can be considered as a good example of multifunctional hall. The hall was designed in contemporary style and reconstructed in 2014. The side and back walls have irregular surfaces and contain perforated panels for sound absorption. Now it is intended for chamber music, piano concerts, but the sound amplification system is also installed in the hall. So the acoustics of the Maliy Hall is adjusted for different musical performances.

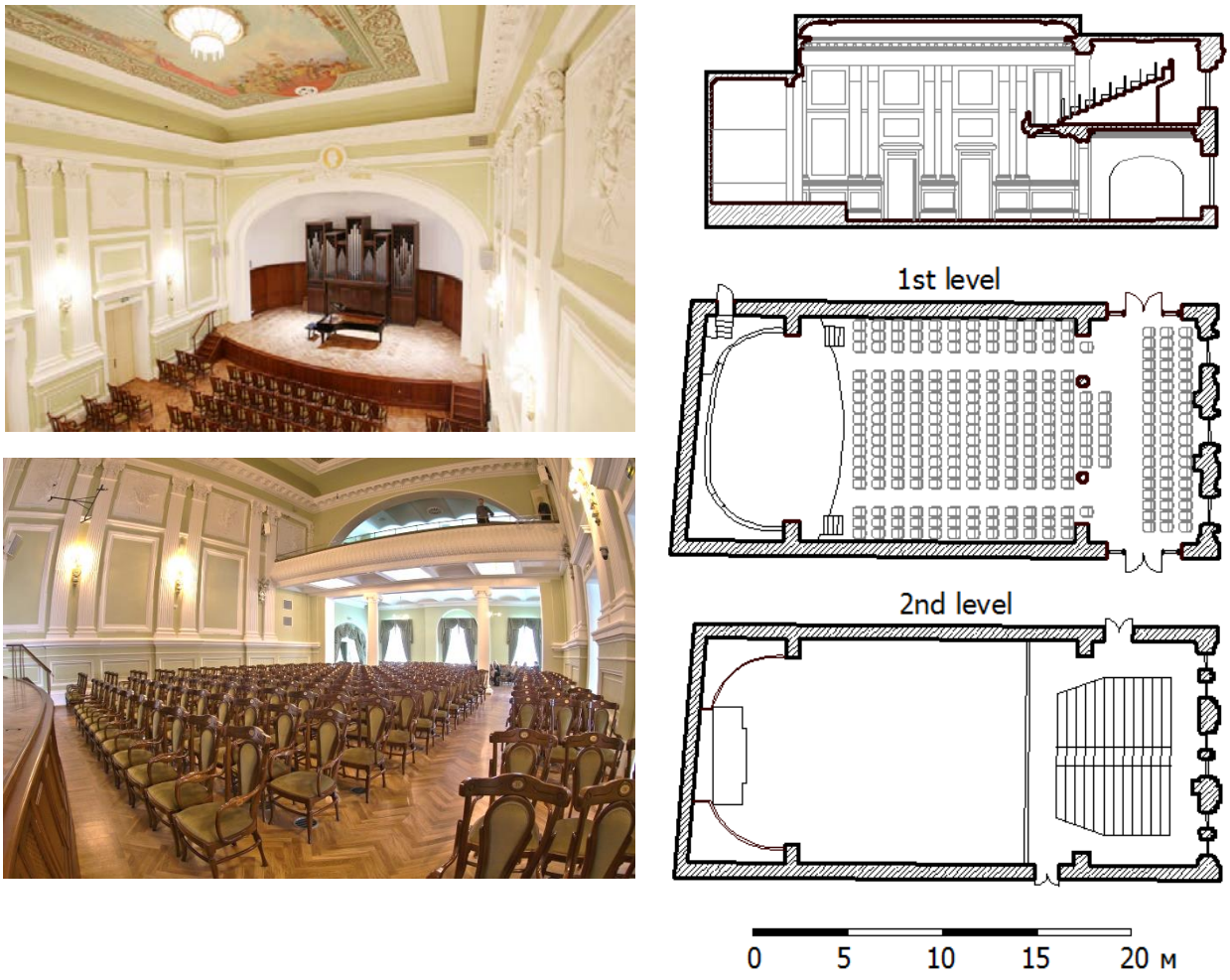


Figure 1. Maliy Hall of the Moscow Conservatory.

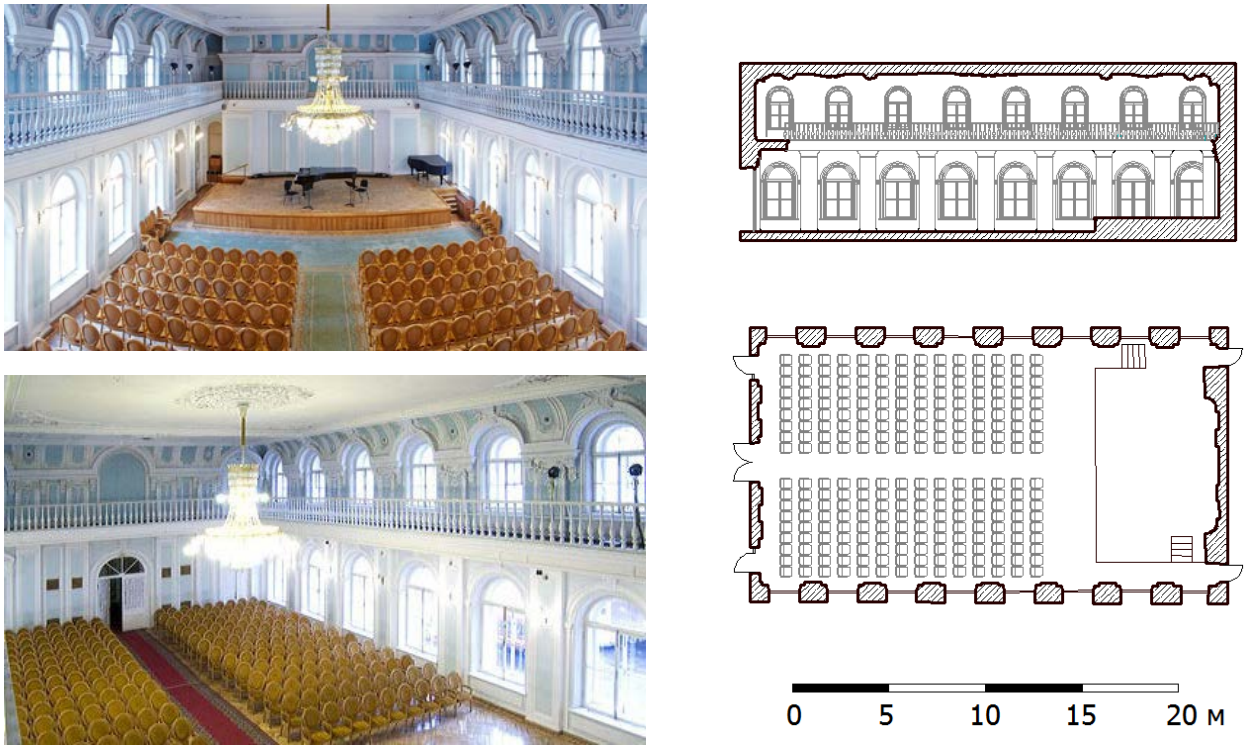


Figure 2. Rachmaninov Hall of the Moscow Conservatory.

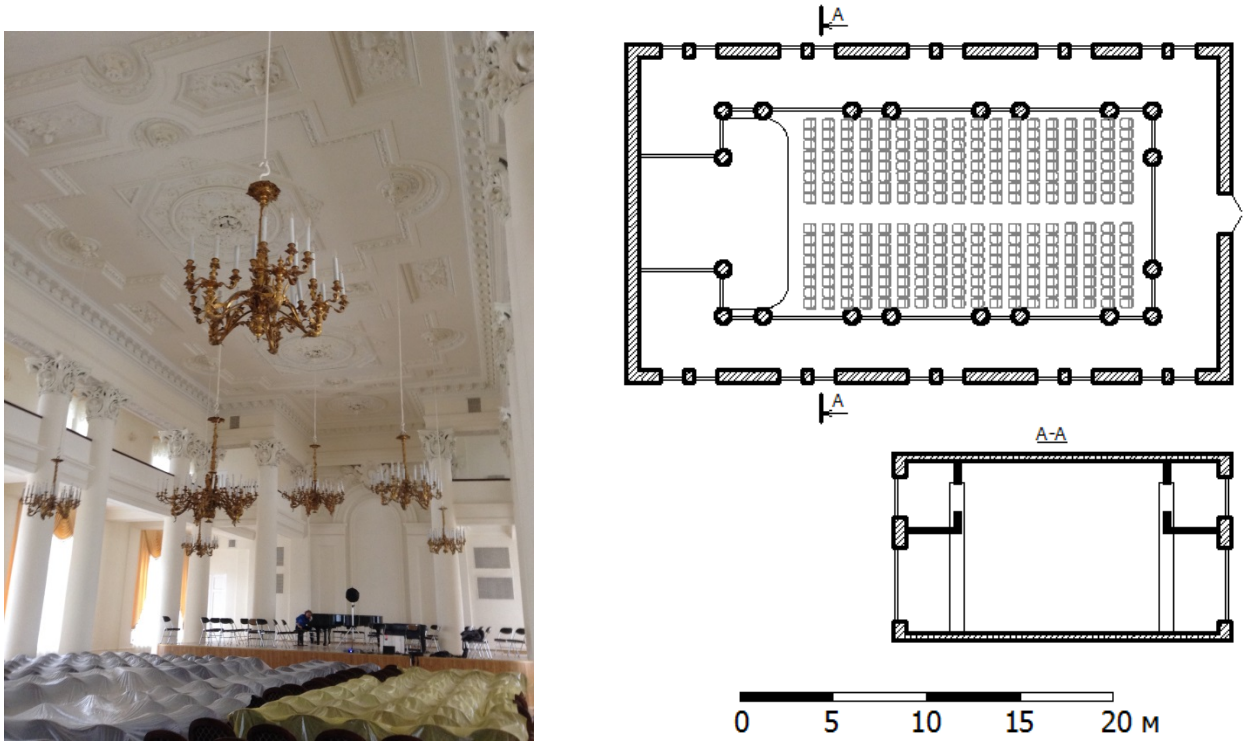


Figure 3. Column Hall of the Tula Philharmonic.

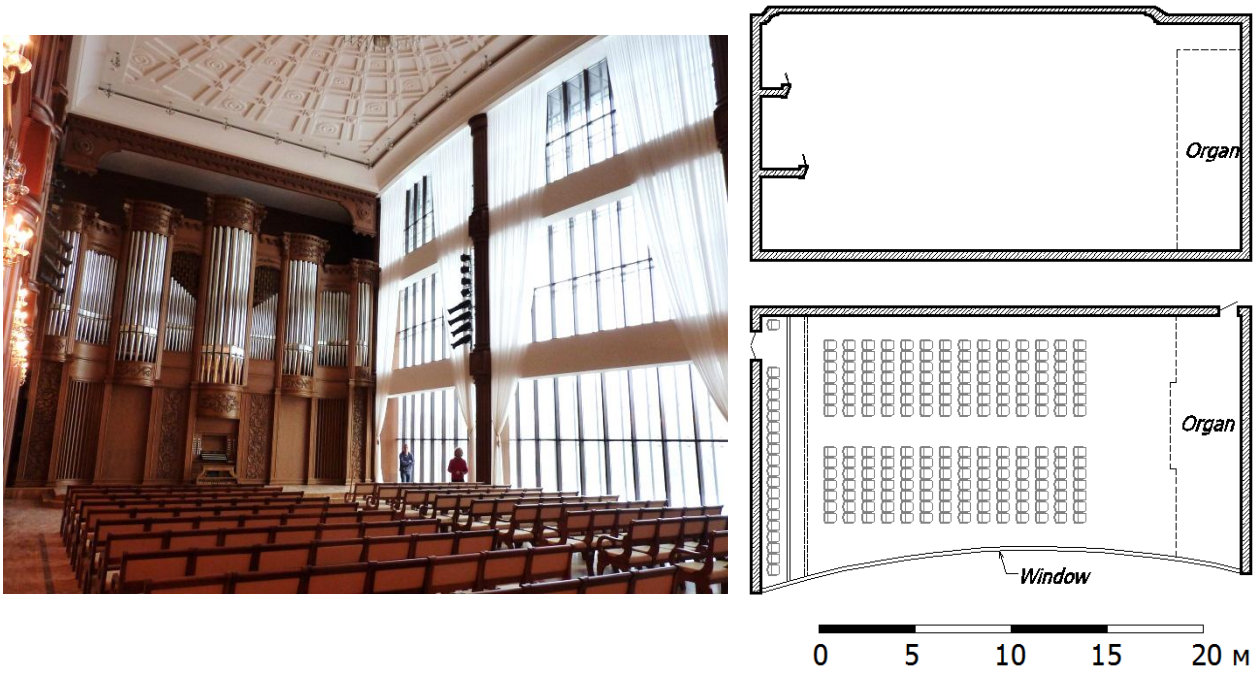


Figure 4. Organ Hall of the Penza Philharmonic.

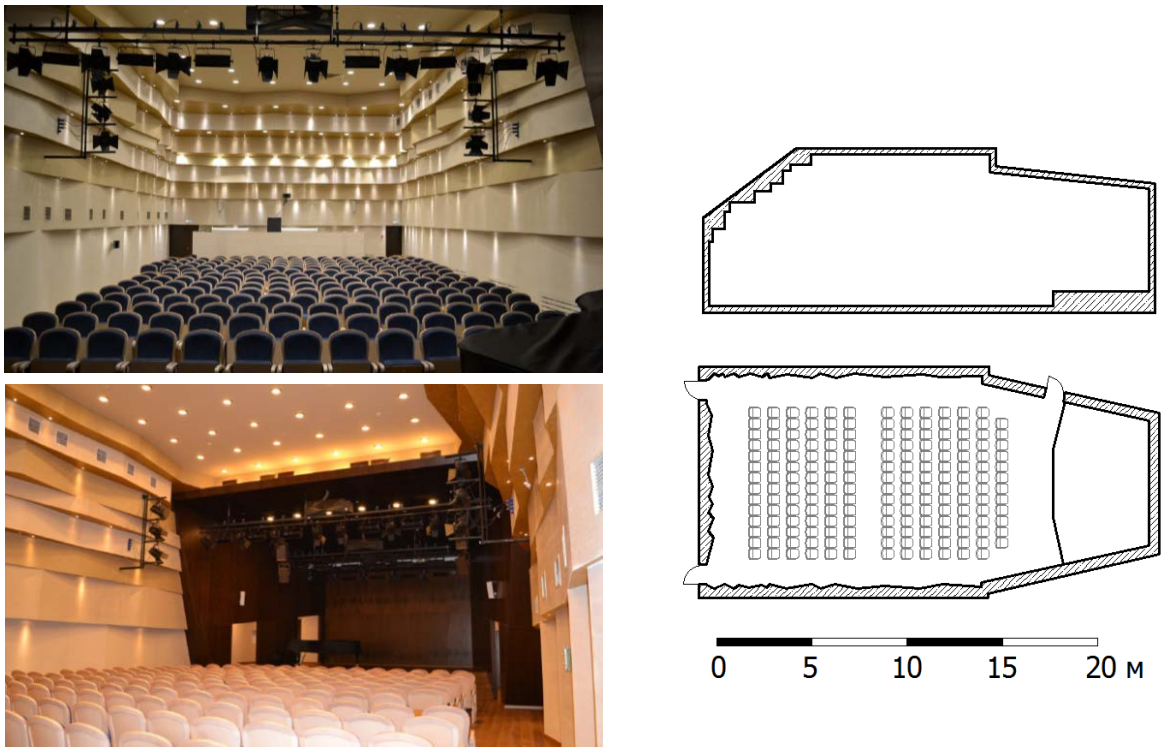


Figure 5. Malyi Hall "Bashkortostan".

3. ACOUSTIC PARAMETERS

Table 1 contains volume, capacity and measured acoustic parameters of the five small halls. In Table 1 we also introduced double letter abbreviations for the concert halls. All the halls are rectangular or very close to rectangular in plan. The only exception is PP, which has a curved side wall. The hall length ranges from 21.6 to 31.0 m. The ratio of length to width is about 1.8-2.2 for different halls, height of all halls is from 7.2 to 12.4 m. The ratio of width to height is very different; in MC and PP it is close to 1, whereas in TP it is 1.8. The seating capacities (N) range from 172 to 436 and the volumes (V) range from 1920 to 4600 m^3. Four halls have large ratio V/N, which ranges from 11 to 16 m^3, the smallest value is 6 m^3 in MC.

Acoustics parameters were measured in the halls without audience and with no instruments on the stage in accordance with ISO-3382. Measured parameters are given in Table 1, where the subscript "mid" means the averaged value of the octave bands 500 and 1000 Hz. Figure 6 illustrates the frequency characteristics of the reverberation time in unoccupied halls. Four traditional (MC, RC, TP, PP) halls have long reverberation time, while in the modern multipurpose hall (MB) it is respectively short.

Table 1. Acoustic parameters measured in unoccupied halls.

Hall	V m^3	N	T_{mid} s	EDT_{mid} s	BR	C_{80} dB	STI	G_{mid} dB	ITDG ms
Maliy Hall of the Moscow Conservatory (**MC**)	2800	436	2.53	2.56	0.93	-3.4	0.39	13.9	19
Rachmaninov Hall of the Moscow Conservatory (**RC**)	2490	252	2.08	2.06	1.05	-1.5	0.47	13.3	15
Column Hall of Tula Philharmonic (**TP**)	4600	300	2.26	2.24	1.18	-2.0	0.43		15
Organ Hall of Penza Philharmonic (**PP**)	3200	200	1.72	1.80	1.23	-1.0	0.46		12
Malyi Hall "Bashkortostan"(**MB**)	1920	172	0.99	0.87	0.94	4.3	0.60		9

In one hall (MC) the reverberation time RT was measured with the audience, but without musicians and instruments on the stage. This measurement is compared with the same in empty hall in Figure 6. Calculation of the reverberation time in the occupied hall by means of empirical method proposed by Hidaka [5] is given in Figure 6 as well. We can see that measured and calculated values in the occupied hall are very close. This verification allows calculating the occupied RT values from measured unoccupied RT values for other halls.

Frequency dependence of the reverberation time can be characterized by RT normalized to the value at 500 Hz. In Figure 7 normalized RTs are presented for traditional halls. We can see the similar dependence for all halls. There are variations between values 1.02 and 1.27 below 500 Hz, at high frequencies only RC differs from other halls. It is interesting to compare reverberation time of the Russian traditional halls with the European and Japanese halls. Figure 7 contains the median values of normalized reverberation time in occupied halls in Europe and

Japan from [3] and the median values for four Russian halls. According to the results the reverberation times of the chamber-music halls in Europe and Russia are very similar.

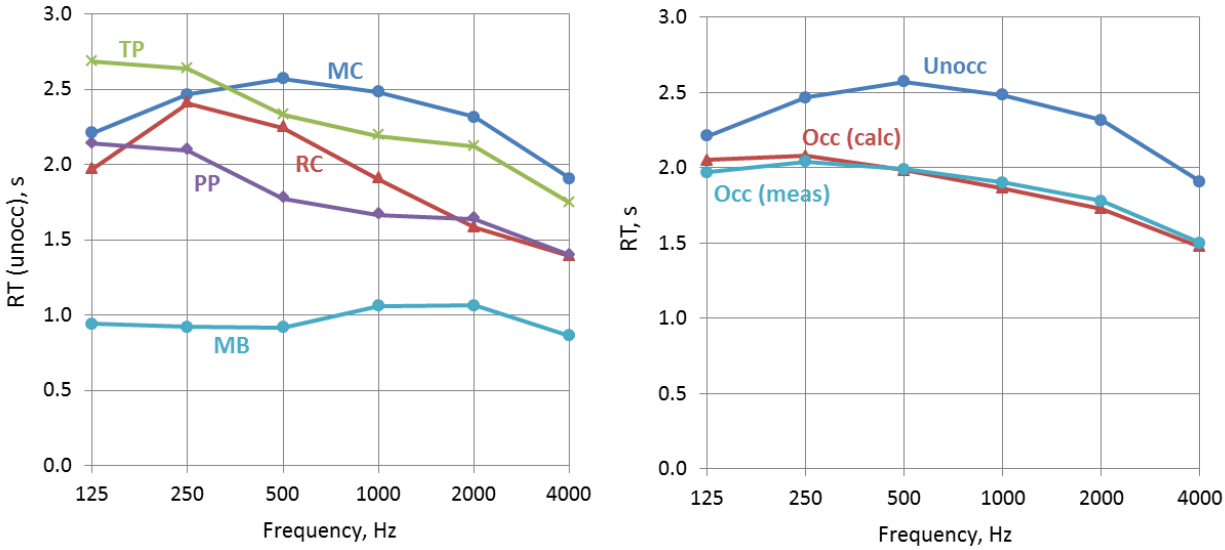


Figure 6. Measured reverberation times in five unoccupied halls (left) and verification of the method for calculation the RT in occupied halls [5] by the example of MC (right).

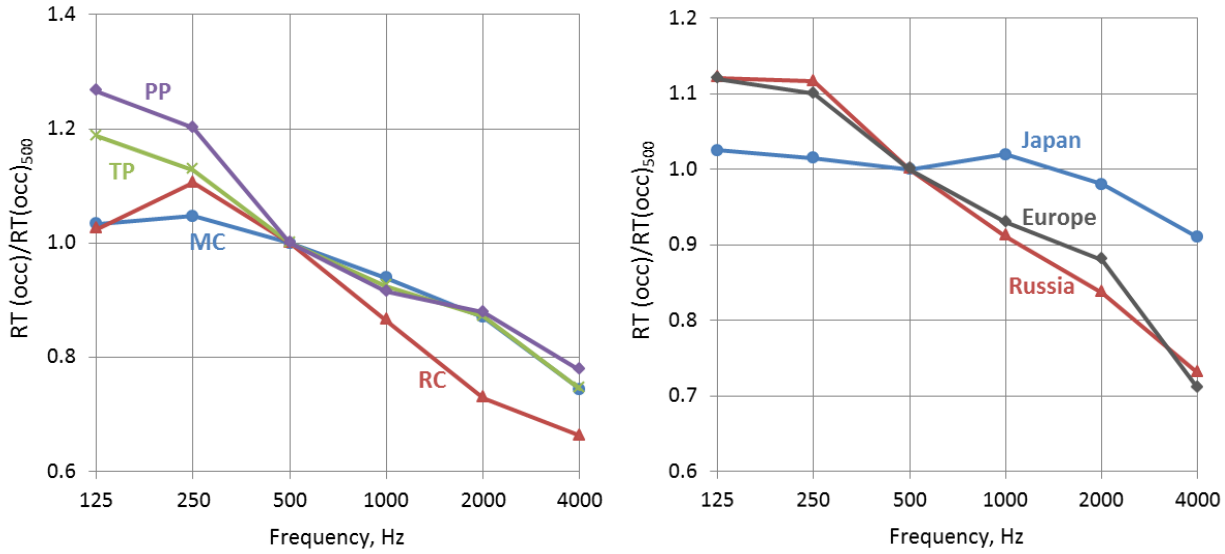
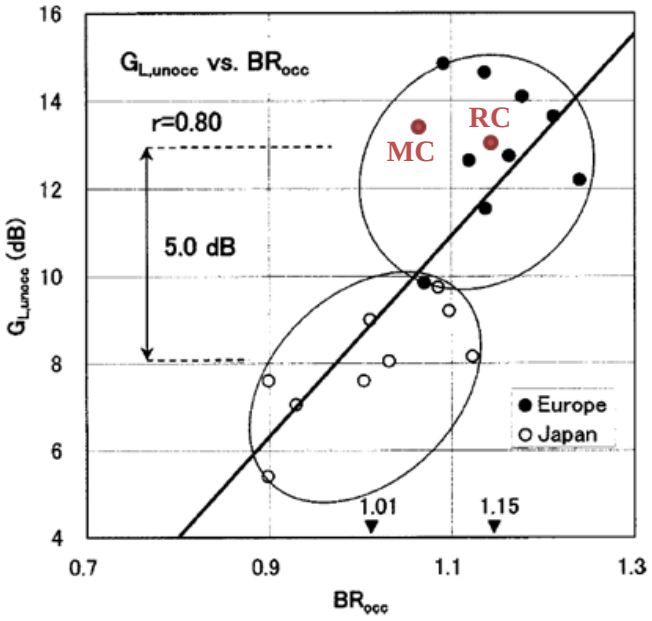


Figure 7. The reverberation times under occupied conditions with audience in four traditional halls normalized to the value at 500 Hz (left) and median values in comparison with European and Japanese Halls [3] (right).

Another interesting comparison could be made for the strength factor G_L (unoccupied) and the bass ratio (occupied). Figure 8 is taken from [3] and contains two points corresponding to the halls MC and RC in which the strength factor was measured. We see that the Russian halls are in the area more typical for the European halls.

Acoustic parameters of the multipurpose hall (MB) differ from parameters obtained in traditional halls. But MB is comparable with modern hall described in [3].



Source: (Hidaka, 2004)

Figure 8. The sound strength G_L (unoccupied) vs. the bass ratio BR (occupied) and GL and BR values for MC and RC.

4. SUBJECTIVE EVALUATION

Figure 9 contains T_{mid} for occupied halls vs. their volumes and optimum reverberation time at middle frequencies according to Russian regulations [6] for the chamber music halls (red line). All traditional halls under consideration have longer reverberation in comparison with recommendations. At the same time some musicians stated that the halls with 500-600 seats had optimal acoustical conditions if the reverberation time was from 1.5 to 1.7 s [3]. Only MC and TP (with maximal capacities) have such capacity and their reverberation is slightly longer as well. In music lovers opinion four traditional halls have very good or excellent acoustics.

At present we have no enough data to give complete evaluation of subjective acoustical qualities of the considered halls. There are several educated opinions collected from the professional musicians and music lovers below.

In all the halls musicians feel comfortable on the stage, even in MB in spite of short reverberation. It seems the small stage of MB and hard walls provide enough acoustic support for musicians. For organ music the reverberation time of MC is appropriate, while in PP it is too short. TP is good for organ music, there is a plan to equip it with a new organ.

Listeners find that traditional halls have good or excellent acoustics. Some listeners consider that MC and RC are too loud especially for piano concerts.

It would be interesting to analyze subjective evaluation of MC before and after renovation which was finished in 2015. The reverberation time change due to renovation is shown in Figure 9 by an arrow. The hall became more reverberant and most music lovers found that the acoustic

changes were positive. Many musicians said that hall's acoustics was preserved. Soloists agree with musicians but they note that the hall became more difficult for singing. The similar evaluations were given after reconstruction of the Great Hall of the Moscow Conservatory in 2011 [4], in which the reverberation time increased from 1.8 to 2.0 s. The reconstruction of the Bolshoi Theatre resulted in increase of the reverberation time of the Historic stage by 0.2-0.3 s. It was evaluated as undoubted improvement of acoustic properties of the Historic stage due to the reconstruction.

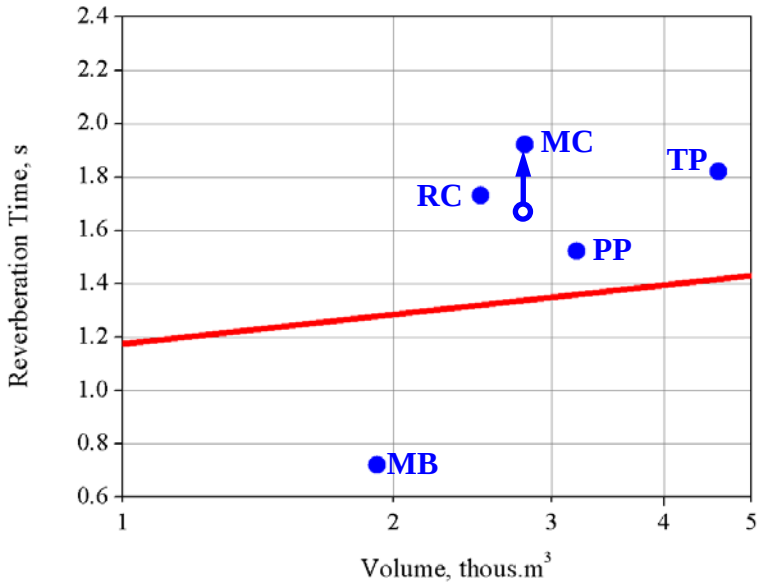


Figure 9. The reverberation times of the occupied halls and optimal RT (red line) according to Russian regulations. The change of RT in MC because of reconstruction is indicated by the arrow.

We can conclude that the audience prefers more reverberant halls for classic and chamber music. Moreover, most acoustic changes in the halls are considered as positive if they result in increasing of reverberation. This observation coincides with the trend revealed by Kravchun for organ halls [7]. During last century the optimum reverberation time was rising from 2.5 to 3.5 s for the hall with volume of 20000 m^3.

5. CONCLUSION

Five concert halls with capacity under 500 seats located in Russia were studied. Four of them have acoustics typical for European chamber-music halls. RC, MC and TP have the reverberation times 2.1-2.5 s at middle frequencies, which are significantly higher than ones recommended by Russian regulations (1.5 s) and found in [3] (1.5-1.7 s). In spite of long reverberation these halls are evaluated as good or excellent by musicians and audience. One of the possible reasons is that subjective preferences have tendency to more reverberant halls.

Many of new or renovated halls are designed for different types of musical performances including those which require sound amplification. MB is an example of new multipurpose hall. Its reverberation time is much smaller than in traditional halls, but conditions on the stage make it comfortable for musicians and soloists. It demonstrates opportunity to combine different functions in one hall, but it is impossible to replace traditional concert halls by multipurpose halls.

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