New room acoustic design concept for rehearsal rooms

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Introduction

During the last decades the design of orchestra rehearsal rooms has changed [1]. Whereas in the past rehearsal rooms were designed to simulate the performance environment, today they are considered as working spaces. In these the focus is set on critical rehearsal conditions consisting of self-control of the own play, hearing other instruments properly and an unadulterated assessment of every single instrument but also of the whole ensemble at the conductor's position [2]. Furthermore rehearsal environments have to ensure that an ensemble is in a position to play only as loud the music (and the conductor!) demands [3].

At the moment no standard-like guidelines for the acoustic design of orchestra rehearsal rooms are known. A room acoustic concept for designing such environments will be presented on basis of several renovation projects of music working conditions in orchestra pits and rehearsal rooms [3 - 5].

State of the art

Regarding the size of orchestra rehearsal rooms disagreement exists. In [1] 25 to 30 m³ and in [6] even 50 m³ per musician are recommended, whereas [7] recommends only 11 m³ per musician as lower margin. Concerning the geometry, [1] suggests an approximate square ground plan with the height about 0.7 times the width, while [7] explicitly warns of choosing dimensions whose ratios are integer numbers. Following [2] it is usually not possible to adjust a suitable reverberation time (RT) for the sound in rehearsal rooms. Furthermore [2] suggests to lower the RT at low frequencies below the value at mid frequencies. [1], however, suggests to design a variable RT in the range of 0.8 to 1.1 s. An increase to lower frequencies (below 250 Hz) should not exceed 1.3 s. A frequency independent RT is suggested by [7]. Sensible sound reflection supports the hearing of other instruments [1, 7]. About 70% of the ceiling should be reflective and the share of early reflections via ceiling and walls should be high [1]. Diffuse reflections from the room boundaries are also important [1, 6]. Recommendation on the clarity at the conductors position are given in [1].

Room acoustic approach

For every rehearsal room redesigned by the Fraunhofer IBP, the ensemble and the conductor were asked about the acoustic quality of the room before and after renovation. The following design suggestions are based on these interviews and on objective measurement results. From the view of music volume, a sufficiently high modal density and a large and flexible orchestra positioning area one can assume that large room volumes and ground areas suit comfortable working conditions. The size of the volume is only restricted by the need of reflecting surfaces for better hearing. The following minimum values, on the basis of 1.4 m² / musician, have turned out to be sufficient. The distance between the conductor and his rear wall should be in the order of 3 m. The same is applicable to the distance between orchestra and its rear wall. The space between orchestra and the side walls should be in the order of 2 m. The height should be about 0.7 of the width [1]. Under such circumstances for a 100 person orchestra the volume calculates to 30 m³ per musician. This agrees with the upper margin of the recommendation in [1]. The length and the width of the room should be chosen such that the ratio of the dimensions is not an integer number.

In order to better hear the own and others play, the RT should be shorter than in performance spaces. Depending on the size of the rehearsal room, the RT should be in the order of 0.5 to 1 s and as far as possible frequency independent in the range from 63 Hz to 8 kHz. The deviation should possibly not exceed $\pm$ 0.1 s. A "variable" RT seems not necessary especially against the background, that musicians usually do not make use of it. In case of doubt the shorter margin of aforementioned interval should be aimed at. Then also the difference due to variable orchestra size is little. The wall behind the conductor must be treated with broad band absorption in order to prevent a virtual orchestra in his back. The same applies to the rear wall behind the orchestra. The side walls, but only the upper half of these, should be designed broad band absorbing. Below they must be reflective and / or only low frequency absorptive. The ceiling can be treated advantageous with low frequency absorbers. In the case of unfavourable room geometry e.g. when the orchestra is placed far from walls, then these have to be treated with broad band absorption in order to reduce detrimental reflections.

To improve the cross communication within the ensemble, apart from partly reflecting side walls and ceiling, a reflector matrix above the orchestra has been proven right. This should be positioned about 3 to 5 m above the ground. For instance by using rectangular reflectors (3x3 m) spaced by 0.4 m, the volume between reflectors and ceiling is still effective. The clarity $C_{80(3)}$ within the ensemble and to the conductor of the order of 4 to 6 dB was found favourable.

Built examples

The users of the rehearsal room of the Staatstheater Stuttgart criticised too high sound levels and a poor cross communication. The ground area is about 22 x 16 m. As a first measure the volume was increased from 1900 to 2800 m³ (28 m³ / musician) by removing the suspended ceiling. Second the front walls were treated with Broadband Compact Absorbers BCA [4], whereas on the ceiling only low frequency absorbers, so called Compound Panel Absorbers CPA, were placed.

Figure 1: CPA and micro-perforated foils on the side walls of the rehearsal room of the Staatstheater Stuttgart.

For the absorption coefficient of these refer to Figure 3 in [8]. The side walls were partly equipped with CPA and in the upper part of the walls also with two layers of micro perforated foils, Figure 1.The resulting RT is shown in Figure 2. Above the orchestra a matrix of reflectors was positioned at a height of ca. 5 m over floor. The feedback of the ensemble and the conductor was positive. Especially the extended musical dynamic range and the possibility of critical hearing are appreciated.

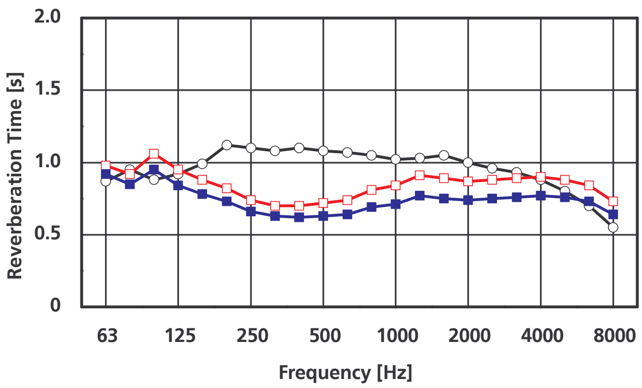

Figure 2: Unoccupied state before (–○–) and after (–□–) renovation; occupied state (–■–) 100 musicians.

A much more unfavourable starting point offered the rehearsal room of the Staatstheater Mainz. With a volume of only 1200 m³, which could not be increased, and a L-shape, Figure 3, which caused detrimental reflections, the room was not suitable for its purpose.

Figure 3: View into the renovated rehearsal room of the Staatstheater Mainz.

Furthermore the RT was too long, Figure 4. Thus, first the "pocket" walls, Figure 3, were covered with BCA in order to reduce the effect of disadvantageous reflections. In addition the remaining walls and the ceiling were treated with CPA and covered by perforated claddings for the sake of architectural design. Only behind the conductor's place broad band absorption (BCA) was positioned. The resulting reverberation time is shown in Figure 4. To improve the communication within the ensemble reflectors were positioned above the orchestra, Figure 3. The clarity $C_{80(3)}$ was increased between the instruments and to the conductor's position from 1 dB to 5 to 6 dB. According to the user, the rehearsal room exhibits a sufficient transparency and enables one to play only as loud as the music (and the conductor!) demands.

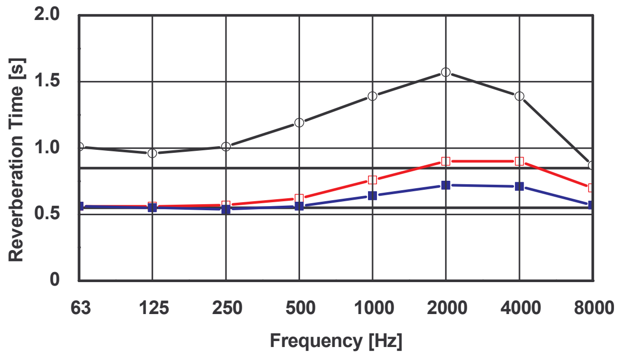

Figure 4: Unoccupied state before (–○–) and after (–□–) renovation; and with 65 musicians (–■–); — tolerance intervall.

Summary

A design concept for orchestra rehearsal rooms has been presented, which aims at reducing the sound load and improving the communication between musicians and to the conductor. By means of novel absorbers two orchestra rooms have been acoustically redesigned.

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